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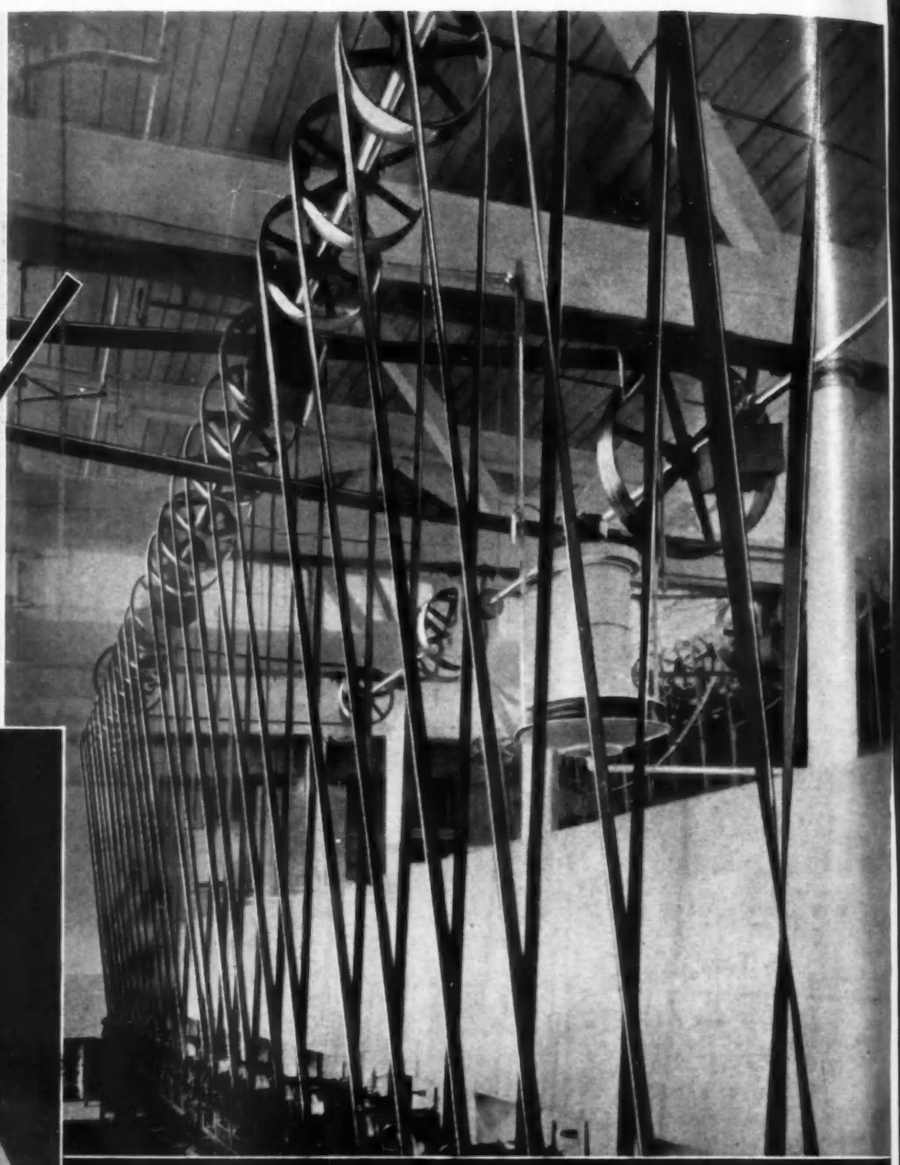

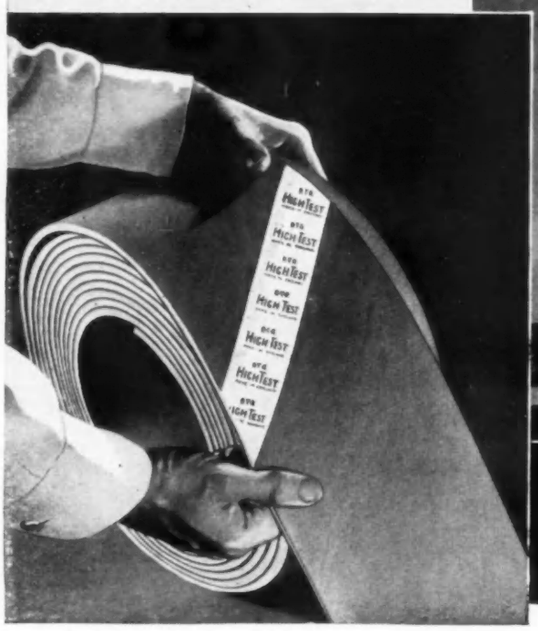

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SAMPLING GAS-BORNE PARTICLES.

THE publication, last year, both in this country* and in the United States of America,† of standard recommendations governing the methods of testing industrial dust-extraction apparatus has directed attention to several important aspects of the general problem of the examination of particles dispersed and conveyed in a streaming fluid medium. It is a problem that arises in a surprisingly large number and variety of scientific and industrial activities, and it has already been extensively considered in such obvious connections as meteorology, water supply, ventilation, boiler operation and the manufacture of gases on a commercial scale. In many of these cases, the chief concern has been to cleanse, by filtration or other means, the fluid from unwanted particulate impurities, and only incidentally, as bearing upon the efficiency of the extraction apparatus, have the particle-laden gases themselves been the subject of detailed study. But with the steady improvement of extraction plant and the multiplication of types and operating principles for different spheres or ranges of utility, what was once an incidental matter has tended to become of primary interest. The most important operation, in other words, is less that of cleansing the particle-laden gases than of comparing the performance of alternative forms of cleansing apparatus.

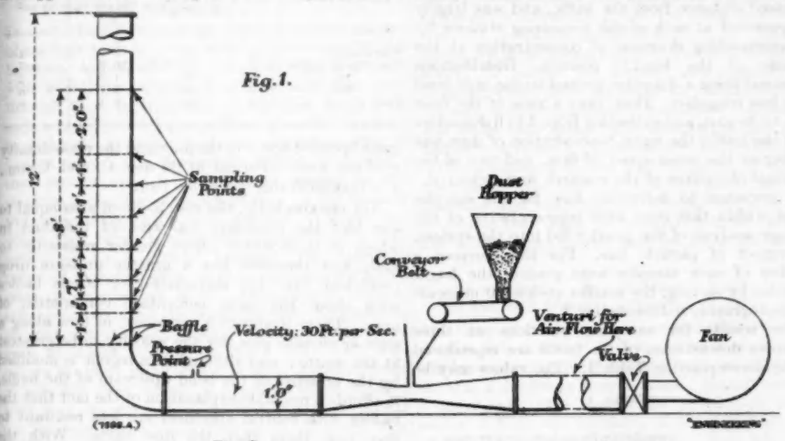
Some of the difficulties involved in this sort of experiment are apparent from the standard recommendations proposed in Britain and America. Equally evidently, from the somewhat tentative nature of these recommendations, uncertainties and errors are still to be expected from more than one source. In some cases, the difficulties are associated with power station boiler plants, which are the principal concern of those responsible for the suggested test codes. Perhaps the most serious troubles, however, are common—or at all events likely to occur—in all cases where the gases to be sampled are flowing in a duct. Under such conditions the distribution of the fluid-borne particles across a section of the duct where sampling measurements can conveniently be made is a matter of great importance, and it may be recalled that a considerable amount of experimental work on this point is described in British Standard No. 893. The objective in view was a perfectly uniform distribution, across a section of the duct or chimney, of the velocity and burden of the gases. Had it been possible to achieve this objective the flow at each and every point within the considered section would have been truly representative of the average flow along the whole duct, and a single sample would have disclosed not only the rate at which particles were being discharged, but also their statistical distribution as regards particle size.

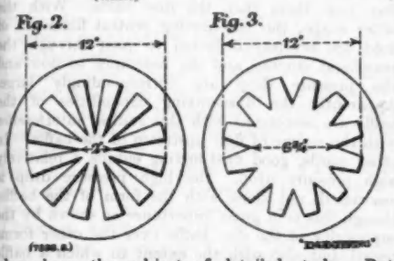
The comprehensive experiments carried out at the National Physical Laboratory in this connection included tests upon guide vanes, honeycomb straighteners, nozzles, and plate orifices; and while none of the devices actually tested was so conspicuously successful that the Technical Committee of the British Standards Institution felt themselves able to make a firm recommendation generally applicable to any of the types of ducts encountered in power station boiler practice, it was a noteworthy feature of the experimental results that simple plate orifices or baffles gave as good results as were obtained by the other, more complicated and expensive, contrivances. The pressure drop across a constricting orifice is probably somewhat greater, as a rule, than that associated with straightening or guiding vanes, but in many practical cases the loss is no more than can be readily tolerated. Apart from this relatively minor drawback, the orifice or damper plate offers a practical and inexpensive method of improving the uniformity of dust-laden gas flow to the point where efficient dust sampling can be achieved.

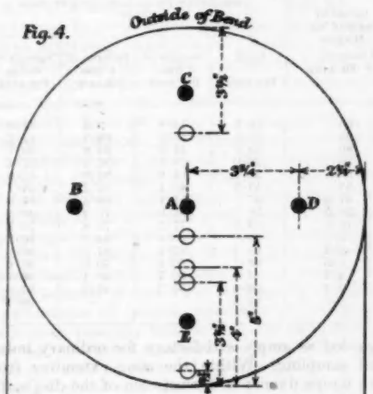
A remark of the British Standards Committee, relative to such orifice baffles, that "better means may be devised by those interested, as a result of experience," lends especial interest to some recent work on the subject carried out by Mr. C. J. Stairmand of the Engineering Research Section of Messrs. Imperial Chemical Industries, Limited. His object was to develop experimentally a type of baffle that would mix fluid-borne dusts so thoroughly as to enable a representative concentration and grading to be obtained from a single sample. It may be said at once that the most successful form of baffle consisted of a central disc surrounded by an open annulus; but before this conclusion was reached several other shapes had been tested and the performances obtained with them present so many points of interest as to warrant some description.

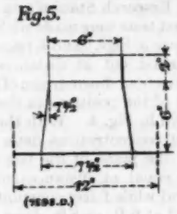
Historically, as well as technically, the investigation dates back to the years 1934-35, when various means of correcting the mal-distribution of pneumatically conveyed powdered coal, resulting from bends in a 4-in. diameter pipe, were studied at the Fuel Research Station. It was found that, in the unobstructed pipe, the velocity variations in the dust-laden air were of the order of ±10 per cent., but that near the bend the concentration varied by several hundred per cent., the majority of the powder being concentrated towards the outer side of the bend. The higher concentrations generally contained the coarser particles, a definite tendency being observed with an upward flowing stream for coarse coal to travel near the pipe wall. Segregation was found to be more pronounced in a horizontal pipe than in a vertical one, or due to a bend as contrasted with an elbow. A D-shaped baffle, obstructing about a quarter of the cross-section of the pipe, was found to be of little use. Better mixing was obtained with a star-shaped baffle, or with a convergent nozzle, although the former of these led to rather excessive concentration of particles near the axis of the pipe. With either of these two latter-mentioned forms the degree of mixing depended upon the pressure drop across the constriction, but it was sufficiently good to justify some further investigation, in the course of which it was hoped to supplement the somewhat meagre available data by observations of the dispersion downstream of the constriction in order to ascertain the optimum position for sampling.

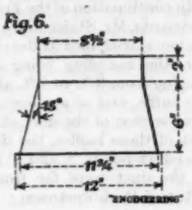
Mr. Stairmand's experiments, accordingly, were made on much the same lines as those previously conducted at the Fuel Research Station, and his apparatus was in all essential respects closely similar, the only notable difference being that his experimental duct was 12 in. in diameter, thus allowing greater accuracy of exploration by an upstream-facing open-ended tube from which the samples of entrained particles were collected in paper thimbles. The general arrangement of the apparatus employed is shown diagrammatically in Fig. 1, from which it will be observed that adjustment was possible of the speed of the air current and of the rate at which the dust under consideration was introduced. The baffle being tested, it will also be noted, was mounted between flanges at the downstream end of a right-angle bend

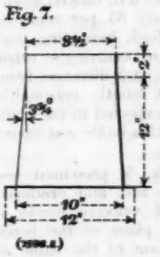


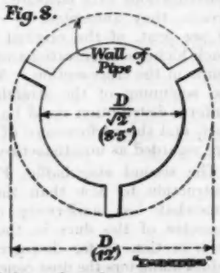












* B.S.S. No. 893-1940.

† *A.S.M.E. Draft Test Code for Dust Separating Apparatus*, 1939. See also ENGINEERING, vol. 151, pages 401 and 461 (1941).

of about 1·5 pipe-diameters radius on centre line, at the junction between the bend and a straight vertical length of pipe in which examination of the particle distribution was made at eight different distances from the baffle. Two arrangements of sampling points, of which details are given later, were used at each of the selected cross sections, and the bore of the sampling nozzle was either ¼ in. or ½ in. For the majority of the tests it may be taken that the mean speed of the air flow in the duct was about 30 ft. per second, while the usual rate of dust input was about 2 gm. per cubic metre of air, *i.e.*, about 1lb. in 6 minutes. The pressure drop across the baffle under test was measured and related to the square of the mean speed of air flow. This pressure drop is of academic interest as regards its general connection with the degree of dust mixing produced by the baffle; and of practical importance from its effect upon the aerodynamic resistance of the whole duct system, and thus upon the fan power required in an actual industrial installation.

In continuation of the Fuel Research Station's experiments, Mr. Stairmand's first tests were made with the two star-shaped baffles shown in Figs. 2 and 3, page 141, the sampling being carried out at distances ranging from 3 ft. to 8 ft. above (*i.e.*, downstream of) the baffle, and at a selection of the positions in the cross-section of the duct shown in Fig. 4. With the first of these baffles, the dust concentrations determined at points A and C in the plane of the bend in the duct were far from equal at distances of 3 ft. to 5 ft. downstream; and while fairly constant concentrations were measured at 6 ft. or 8 ft. downstream, they amounted to only 65 per cent. to 80 per cent. of the original feed, indicating that much higher concentrations were occurring at other points in the cross-section. At such distances from the beginning of the straight length, reasonably uniform distribution could be expected in the plain duct, and the performance of this baffle was therefore regarded as unsatisfactory.

The second star baffle, Fig. 3, presented less obstruction to flow than the first and produced somewhat less uniformity of velocity across a diameter of the duct in the plane of the bend. At a section as far downstream of the baffle as 8 duct diameters the dust concentration was uniform and fairly close to the mean value, but at sections nearer the baffle the concentrations alternated above and below the mean. Thus, the indications were that the powdered coal was being deflected from side to side across the duct; and while correct readings were obtainable at certain points, such points were undesirably local, their positions could not be predicted, and the mixing was evidently not really uniform.

In view of these unpromising results with star-shaped baffles, attention was turned to conical nozzles, of which the three patterns illustrated in Figs. 5, 6 and 7, page 141, were successively tested. In each case the design comprises a step or annular baffle, adjoining the wall of the duct and intended of itself to produce some degree of dust mixing; and a convergent cone which tends to spread towards the centre the high concentration normally found near the periphery of an unobstructed pipe. The first of these nozzles (Fig. 5) was found far too severe in its action, practically the whole of the entrained powder being deflected to the axis of the duct. The second (Fig. 6) with a very narrow step leading to a more rapidly convergent cone, showed little improvement, velocity and concentration both being badly distributed as far as four duct diameters downstream, while the powder was again too severely deflected to the centre. The third nozzle, Fig. 7, was given a very slight taper and a step of moderate width. It gave uniform velocity distribution at all points more than four duct diameters downstream but the distribution of entrained powder was erratic.

The lack of success with two not unreasonable forms of mixing baffle led the investigator at this stage to make some visual flow experiments with various forms of obstruction mounted in a transparent pipe. Water and sand were used to slow down the motion so that it could be more easily observed. Tests with an annular plate confirmed the previous experiments, showing that the entrained particles were almost entirely deflected to the axis of the pipe with very little mixing effect. The reverse form of obstruction, consisting of a central disc surrounded by an annular opening, gave, on the contrary, a promising flow pattern, and the mixing appeared to be very thorough at all sections downstream.

A disc baffle of the form shown in Fig. 8, page 141, made of 16-gauge mild steel plate and having three slender arms gripped between the pipe flanges so as to hold the circular part centrally in the duct, was accordingly fitted into the 12-in. pipe and tested as before. The air velocity at 4 and 6 diameters downstream was found to be remarkably uniform along diameters both in, and normal to, the plane of the bend in the duct. Only slightly less uniform were the concentrations of coal dust, also measured in and across the plane of the bend, at distances from 3 to 6 pipe diameters downstream of the baffle. Such irregularity as was observed was an increase of particle concentration on the "outside of the bend" side of the duct. It decreased progressively with increased distance from the baffle, and was largely compensated at each of the measuring stations by a corresponding decrease of concentration at the "inside of the bend" position. Distributions measured along a diameter normal to the pipe bend were less irregular. Thus, over a zone of the duct close to its axis, and extending from 3 to 6 diameters from the baffle, the mean concentration of dust was passing at the mean speed of flow, and two of the principal objectives of the research were achieved.

It remained to determine how far the samples taken within this zone were representative of the average analysis of the powder fed into the system, in respect of particle size. For this purpose a number of such samples were graded, the larger particles by sieving, the smaller (below 50 microns) by photographic sedimentation.*

The results for sampling positions at three distances downstream of the baffle are reproduced in the accompanying Table I. The values may be

TABLE I.

Grade of Particle Size Micron. 1 micron = 0·001 mm.	Cumulative Percentage Greater than Grade.			
	Feed. Per cent.	Sample at 3 dias. Per cent.	Sample at 4 dias. Per cent.	Sample at 6 dias. Per cent.
125	10·7	11·8	9·3	11·9
105	15·9	16·6	14·5	19·2
89	23·0	24·9	24·8	30·7
76	26·0	29·3	32·1	37·2
66	30·5	34·6	38·0	42·8
53	43·3	42·1	53·3	54·7
37·5	57·1	51·1	60·4	61·4
26·5	76·7	66·9	71·9	66·1
18·8	85·9	77·2	79·8	76·1
13·2	90·7	80·4	84·0	86·7
9·4	94·4	87·1	87·6	93·0
6·6	96·7	90·6	90·0	95·6
4·7	97·9	93·7	93·1	96·7
3·3	98·6	95·2	95·2	97·8
2·3	99·3	—	—	98·7

regarded as amply satisfactory for ordinary industrial sampling. Within the zone extending from 3 to 6 pipe diameters downstream of the disc baffle, samples taken at a single point on the axis of the pipe give the true concentration and grading of the dust within about 5 per cent., while over the whole of the cross section the distribution is uniform to within some 10 per cent.

Experiments with disc baffles of different sizes reveal that the obstructing disc should occupy at least one half of the cross-sectional area of the duct. When the dust-laden gas is known to be spinning violently, for example as the result of passing through a cyclone separator, an additional precaution essential for accuracy is to mount a simple cross baffle immediately upstream of the disc. Such a baffle, or straightener, consists of two plane rectangular sheets, each as wide as the duct diameter, each from 1 to 2 diameters long, and intersecting at right angles along a central line coincident with the axis of the duct. It is noteworthy that the satisfactory mixing obtained with the disc baffle, with or without the additional cross baffle, occurs when the baffles are mounted at the upstream end of a length of straight duct in which the general direction of fluid flow is vertically upward. It is probable that good results would also be obtained with downward flow in a vertical duct, but in a horizontal duct an undesirable segregation of the heavier particles, due to gravity, is to be expected.

A final point of interest concerns the pressure required to overcome the resistance to flow through the various forms of baffle tested. For the range of duct size and speed of flow likely to be encountered in industrial practice, scale effects are probably negligible and it may be accepted that the pressure drop for any shape and size of baffle is proportional to the product of the density of the fluid and the square of the mean speed of flow.

Some results are given in Table II, where the pressure drop coefficient $\frac{p}{\frac{1}{2}\rho v^2}$ is based upon the

TABLE II.

Form of Baffle.	Fig. No.	Mean Speed in Duct, v (ft. per sec.)	Pressure Drop. p (lb. per sq. ft.)	$\frac{p}{\frac{1}{2}\rho v^2}$
Star shaped ..	2	30	1·5	1·4
Convergent nozzle	5	30	10·2	9·7
Do.	6	30	1·3	1·2
Do.	7	30	1·7	1·6
Disc	8	30	5·1	4·8

mean speed of flow v in the duct and the mass density ρ of the fluid. For air at 20 deg. C. and 1 atm., $\rho = 0{\cdot}002336$ slug per cubic foot.

Not unexpectedly, the disc baffle of area equal to one half the cross-sectional area of the duct in which it is mounted offers greater resistance to flow, and therefore has a greater pressure drop coefficient than the star-shaped or nozzle baffles with about the same percentage constriction of area. There is always a tendency, in flow along a duct or circular pipe, for the velocity to be greatest at the centre; and although this regime is modified by the presence of the bend upstream of the baffle, it affords a probable explanation of the fact that the baffles with central apertures are less resistant to flow past them than the disc baffle. With the latter shape, the fast-moving central filaments of fluid are severely deflected to pass through the peripheral annulus and the resistance to flow and the pressure drop are correspondingly large. Apparently the dust-mixing capabilities of the baffle are associated with this radical interference with the regime of flow upstream of the baffle. In other words, good dust-mixing entails a relatively high pressure drop. The high pressure drop is associated, not alone with the form of the baffle, though this is of great importance as shown by the superiority of the disc baffle over the other forms tested, but also with the extent to which a baffle of good form obstructs the free flow along the duct. Doubtless this is the reason why the investigator has recommended that, for satisfactory mixing, the disc baffle should occupy not less than one half the cross-sectional area of the duct. The pressure drop observed, and given in Table II for the actual arrangement and a mean air speed of 30 ft. per second in the 12-in. pipe, amounts to about 1 in. of water head. This is quite appreciable but should not unduly strain the resources of an industrial installation.

When a satisfactory distribution of the dust carried in a stream of gas has been assured by some such means as the disc baffle just described, the next problem encountered is commonly that of sampling the dust-laden gas. This operation may be undertaken either to examine the actual, perhaps unavoidable, dust content of an untreated gas-stream; or as a means for determining the efficiency of dust-extraction apparatus. In the latter case downstream of the extractor, and under certain conditions in the former case also, it is to be expected that the dust content is small and the particles of small size. On the other hand, for the purpose at issue, it is of importance to ensure that practically the whole of the particulate matter is removed. The sampling and filtration is thus a much more refined operation than the ordinary industrial dust extraction, and in British Standard No. 893 several forms of filter suitable for efficiency measurements on extraction plant are described. Since such

* *Trans. Inst. Chem. Engrs.* Size Analysis by Photo-sedimentation, by W. F. Carey and C. J. Stairmand.

efficiency tests are a considerable and infrequent undertaking, they justify the use of high-grade, fine porosity, filters like alundum thimbles, and of the high-suction pump necessary to withdraw the sample of gas through the filter. But for many sampling purposes, especially those of a routine character in the chemical industry, or where the particulate matter takes the form of an oil mist, the need arises for sampling filters that will strain out the finest particles without being unduly resistant, and of such forms that the collected matter can be completely, readily and certainly recovered.

(To be continued.)

LITERATURE.

Modern Machine Tools. By H. C. TOWN, A.M.I.Mech.E., M.I.P.E. London: Sir Isaac Pitman and Sons, Limited. [Price 30*s.* net.]

IN view of its fundamental importance, the subject of machine tools is not as well represented in British literature as it should be. It is true that it is dealt with widely in current periodicals and that only through them is it possible to maintain touch with such a rapidly-developing sphere of work. Articles in technical journals, however, are necessarily of limited scope, and frequently highly specialised; they can be viewed in their true relation to the machine-tool sphere as a whole only on the basis of wide general knowledge of the subject. The purpose which they serve is altogether different from that performed by a general treatise. The complete range of machine tools involves such an enormous mass of specialised detail, that many writers, attempting to cover the whole subject, have split it up into sections each dealing with one main type, such as lathes, drilling machines, etc. This procedure is apt to result in a collection of descriptions of selected tools, in which fundamental problems, that may be common in various types, are likely to be overlooked. Considerations affecting the design of, say, a feed box may have equal bearing in a lathe, a radial drill, or a milling machine.

In this valuable work, Mr. Town has dealt with his complicated subject in a novel way, splitting it up into three main sections, concerned respectively with mechanical transmission, electrical transmission, and hydraulic transmission. In a sense, this division is just as arbitrary as one based on tool type, but it has the great advantage of enabling any particular feature of design to be dealt with in terms which cover its application to any form of tool. Chaper I, which opens the section of mechanical transmission, is concerned with belt drives. The arrangement of a drive of this kind applied to a boring mill may be different from that adopted for a lathe, but the fundamentals of design are not. As throughout the book, the treatment in this section is concerned with the basis of design, not with mere description, and tables of speed ranges, curves of power transmitted, etc., are given. This chapter forms a very small part of the book and Mr. Town in no way overlooks the fact that the tendency is more and more towards self-contained drives. The chapter is particularly referred to, as it forms a convenient illustration of the method of treatment adopted throughout. It also forms an important item in the whole subject. The simplicity and cheapness of the belt drive are such that it is likely to continue to be applied for many years.

Chapter II, of the mechanical transmission section, is concerned with gearbox drives, but after that, even with Mr. Town's method of treatment, it has been necessary to give separate chapters dealing with various classes of machine: capstan and turret lathes, grinding machines, reciprocating machine tools, and so on. The main mechanical features of machine-tool design are covered in these chapters, and such matters as the power operation of slides, gear calculations, cam diagrams, spindle bearings, etc., are dealt with in their appropriate connection. There is possibly a certain amount of overlapping; for instance, cam diagrams are referred to in more than one chapter. This, however, is not only unavoidable, but is desirable. The matter is dealt with from the point of view of design, but not on the lines of a text-book on applied mechanics. The treatment has reference to the special problems of machine tools and in all cases is linked with practical applications, of which examples are given. The chapters contain a fair number of detailed descriptions of machine tools, but these are selected to illustrate the application of principles and there is no attempt to deal with a large number of makes simply because they may differ in detail arrangements.

The section on electrical transmission is likely to prove of considerable value to present-day designers. It brings together a large amount of information, illustrating the achievements and potentialities of both electric drive and control. It will not turn a machine-tool designer into an electrical engineer or vice versa, but it will enable them, in combination, to learn what has been done and to envisage possible developments. Many highly-specialised matters are dealt with in an informative way, such, for instance, as automatic sizing. This remark also applies to the section on hydraulic transmission; and the chapter on valve gear for hydraulic machine control, for instance, presents a large amount of specialist information for which, to collect for himself, the machine-tool designer would have to make an extended search through technical journals, institution proceedings and trade catalogues. The advantages and possibilities of hydraulic operation are dealt with in an earlier chapter and the various types of pumps described. The book is well produced and the diagrams and drawings are reproduced to a scale at which they may be studied without fatigue. The volume is a valuable contribution to its subject.

Plastics in Industry. By "PLASTES." London: Chapman and Hall, Limited. [Price 12*s.* 6*d.* net.]

ALL those who have been concerned with the introduction into industry of new processes or materials will know the many difficulties which can arise when there is a departure from routine. Manufacture on a large scale often reveals the presence of unsuspected defects, the influence of impurities and the effect of a different source of raw material, while a change in some minor dimension of a tool may have surprising consequences. Further, the use of a product on a large scale may show that the tests adopted served admirably to control every quality save the one which unskilled use proved to be essential. Even the name of a material may have unfortunate effects; the former custom of labelling new products as "artificial" may be cited as an example. Although the plastics industry is not rich in standard specifications to guide the steps of the user, it is fortunate that there is a rapidly growing body of literature to which recourse can be had for information. The book under review, which is of frankly commercial interest, is a useful accession, because it not only reviews the industrial applications of plastic materials, but indicates, wherever possible, their mechanical and other properties and gives much information about applications and methods of manufacture. A short account of the chief plastics is given and from the chapter on specifications it appears that Great Britain leads in the provision of these essential aids to mass production. Notes on moulding and fabrication technique precede a series of chapters on applications in various industries—engineering, chemical engineering, aircraft, textile, and so on. Potentially important applications are not neglected, and the reader is further helped by observations on design, display and packaging. The presentation of the book is excellent and the price reasonable. The inclusion of a table summarising the trade names, properties and characteristics of the principal plastic materials would have been a useful addition.

WORLD PRODUCTION OF TIN.—The current issue of the Statistical Bulletin of the Tin Research Institute shows that the world production of tin in June was estimated to be 29,400 tons, compared with 22,900 tons in May. The production for the first six months of the present year totalled 127,400 tons against 105,200 tons in the corresponding period of 1940. During the first half of 1941, the total delivered to the United States was 80,372 tons, compared with 50,609 tons in the corresponding period of 1940.

ECONOMIC CONTROL IN INDUSTRY.

By F. L. MEYENBERG, M.I.Mech.E.

(Continued from page 75.)

THE preceding article showed that economic control deals with a works as it is, and is not concerned with the further development of plant and equipment. Of course, conclusions drawn from the results of economic control will often decide new expenditure and its methods will be employed to determine where and how such expenditure should be applied; but these considerations are outside the scope of the present discussion. It is a sound and well-proved principle to make the best of the existing plant before altering or enlarging it.

One of the main groups forming the subject of economic control is that of material in its various forms as raw material, semi-finished and finished goods, and as auxiliary material for production, workshops and offices, including the cost of power, heat, and light. If a clear impression of the state of affairs in the works is to be obtained and kept, it is necessary to define exactly how material should be classified into these groups. A useful basis of classification is to regard as "raw material" everything that has been bought outside and is not yet charged with any wages apart from the cost of unpacking, unloading and transport to the stores. This group includes, therefore, not only rods, bars, sheets, wire, etc., but also castings and pressings, screws, nuts, bolts, and such instruments as tachometers, gauges, etc., so long as these have not been produced in the works. "Semi-finished" goods comprise everything that is in course of production; that is, which is being charged with production wages, but is not so far advanced that it can be transferred into the finished stores. "Finished goods," as the term implies, means goods that are ready for delivery. Auxiliary materials are those which are necessary for production, but which are consumed more or less during the production process and, therefore, cannot be individually identified in the finished goods, such as soldering and welding material, etc. Typical auxiliary materials for the shops are brushes, cotton waste, lubricants, etc., necessary for keeping the shops and equipment clean and in proper condition; auxiliary materials for offices mainly comprise stationery. The cost of power, heat and light is included in this category when there is no power station in the works, and electricity, gas, etc., must be purchased from outside.

Even these definitions are only a guide and may leave doubts in a special case, to which group a material should be allocated. Such definite allocations, however, should not be omitted, since they are necessary for keeping the survey as well as for costing purposes. Some materials may have to be transferred from one group to another in a special case, and the organisation must provide means for effecting this. All material other than semi-finished goods in course of production should be kept in the stores and properly checked in or out. This may appear obvious, but in practice it is an easier rule to make than to carry out, for it applies not only to definite items of the production, but also to the return of material delivered to the shops in excess of actual requirements, such as short ends of rods, small parts of sheets, etc., as well as scrap and rejects. The tendency of the shops to keep such material back, to use it on similar work in future or, perhaps, to cover up mistakes, must be overcome; experience shows that it can be done, and to an extent which advocates of less rigid methods declare to be impracticable. It has even been found economical, in special cases of mass production, to determine the difference between the theoretical and the actual scrap, and to find out whether this loss by crumbling has been kept within tolerable limits.

Without going into the details of the often rather complicated organisation necessary for the purposes explained, some problems may be mentioned which are often discussed, and regarding which differences of opinion persist. Who is responsible for issuing the requisitions on which material is delivered from the stores to the shops? A general answer cannot

be given; but modern organisation tends towards a planning department which should issue at least the requisitions for the main material. The organisation should not be so rigid, however, that the shops themselves cannot do this in case of emergency; for instance, if, otherwise, a delay in production would occur. Care must be taken, of course, that such exceptional measures are brought quickly to the knowledge of the planning department. As soon as an order is sufficiently advanced for planning the main materials should be reserved in the stores' books—usually a card index—so that the stock materials actually available are clearly shown; this method should be limited to the main materials, as the considerable work of organisation connected with it cannot be justified in less important cases.

Material in the stores may be valued in three ways, namely, on the book value, the market price, or a fixed standard price. All three have their advantages and disadvantages, but it is usual to take the book value; not only because the connection between the stores book-keeping and the accounts is then very simple, but also because the personnel commonly employed in storekeeping understand the development of this price best, and think on this basis.

The book value should be, for raw material, the price taken from the supplier's invoice, increased, if necessary, by the cost of transport to the works. Charges for transport and storage within the works should not be added, but should be regarded as overheads. For finished goods, the value should be the production cost; that is the cost of the material used, plus the wages charged against the particular finished goods, plus all overheads with the exception of the selling costs, which should be charged to the finished goods only after delivery to the customer or erection on site. For all kinds of auxiliary material, the same considerations apply as for raw material.

What has been described so far may be regarded as the routine work of economic control of material, so simple in principle as to seem hardly worth description; but the putting of these principles into practice is difficult and requires constant supervision if mistakes are not to creep in which, although individually small, may be numerous enough to give incorrect results. It should be remembered that this kind of work depends on the co-operation of a number of only semi-educated personnel. If, however, nothing more than this routine work were done to control material, it might almost be omitted altogether, as no adequate benefit would result if the stores records of stocks, and material received and issued, constituted the only stores control. They should only form the basis for further consideration of how more economical working may be achieved.

Dealing first with raw material, questions may arise whether the control in the receiving department and in the test house is adequate. The percentage of rejects because dimensional tolerances have been exceeded; quantities in excess of those ordered; defects evident from inspection or on test, or which may be discovered in machining; any of these causes may lead to a change of supplier or to a claim for damages. The increase and decrease of stocks and available material must guide buying policy; and the variety of material, in quality and dimensions, may indicate the need for closer standardisation. These are typical considerations which serve to show how the control of raw material is bound up with the work of the purchasing and receiving departments, of the testing and inspection organisation, and of the designer and producer.

These considerations also apply to finished goods, adapted to the different conditions; but, in this case, regard must be had to another aspect of special importance, namely, whether the design and the methods of construction together represent the most economical means of producing the various parts of a finished product. It depends on the plant and equipment, the skill with which they are employed, and the amount and urgency of the work in hand, whether some parts which could be made on the premises would not be better bought outside, and what change of design or production methods would be justifiable in that case. Such decisions, of course, should be based, as far as possible, on the figures given by the costing system; although they will be influenced by other factors, to which a cash value cannot always be given. Control of auxiliary material is facilitated by establishing standard rates of consumption, based on experience; in the case of what has been termed "auxiliary material for production," these may be expressed per unit of output, and auxiliary material for the shops or offices, per working week.

Control of the cost of power is often regarded as unnecessary, because any possible saving appears to be hardly worth the trouble involved, but there are many losses which are readily avoidable; for example, by improvement of the load factor, decreasing friction losses in shafting by improved lubrication or use of roller or ball bearings, increasing the efficiency of belt drives, grouping machines so that complete lines of shafting can be stopped during slack times, and avoiding losses by leakages of compressed air, water, etc. Heating costs can be kept reasonable by adjusting the temperature in individual rooms according to the kind of work carried on. Where distant control by electrically operated recording instruments is too expensive, a fairly frequent visit by a special observer has produced good results. In spite of all that has been said and written about the importance of correct lighting, this is not yet sufficiently appreciated in practice; in a series of investigations, an increase of output of between 10 per cent. and 35 per cent. was observed by increasing the expenditure on lighting by between 1 per cent. and 5 per cent. of the wages paid.

There are some features of material control which are often overlooked and which render its satisfactory solution rather more difficult than commonly appears at first sight. Everything is in a constant state of flux in an industrial works, and outside conditions, which also influence operating conditions, are changing continuously; so that the arguments and conclusions which are correct for a particular investigation must be checked from time to time to ensure that they are still valid. It is for this reason that experience, valuable as it is as a guide, is not sufficient without careful examination of the basic reasons for decisions.

For example, orders for material of standard quality and dimensions are frequently issued on the maximum-minimum method; *i.e.*, on the index-card for this material is indicated a minimum below which the stock must not fall, and a maximum which should not be exceeded. These limits are nearly always fixed according to experience; but, even if that is done with the greatest possible care and due regard to the usual waiting period before delivery, the capital invested in the stock, etc., such figures will not hold good for long under the constantly changing conditions of modern business. They need to be kept continually under observation; and any expert organiser will admit that, in the majority of industrial works, this continual observation is not made. This does not mean that the method is useless; on the contrary, no better method is known to the author, and it is always preferable to have some guide rather than none at all.

But it cannot be emphasised strongly enough that imagination must supplement experience in the economic control of material. This introduces the great difficulty that, for a function requiring the accuracy and care, or what might almost be termed the pedantry, of a skilled book-keeper, someone is needed who possesses sufficient imagination and mental alertness to be able to anticipate future developments and their consequences: a person combining such contradictory qualities that it seems almost impossible to find him. If he can be found, every effort must be made to keep him; and the best man will be retained only if the position of chief storekeeper has a more independent, and higher, status in the works than is at present usual. He should not only be on a par with the chief accountant and the manager of the purchasing department, but should also be able to deal on terms of equality with the chief designer and the production manager.

(To be continued.)

AMERICAN SYNTHETIC SAND PRACTICE.*

By NORMAN J. DUNBECK.

WHEN metal is cast against moulding sand, the clay contained in the sand close to the casting is dehydrated and loses strength. It is further weakened by normal accretions of burned core sand. This weakened sand often is discarded, although it may be as good in refractory value and grain structure as when it was new. Many foundries now add bonding clays to restore strength, and in this way, effect elimination of new bonded sand or a considerable reduction in the amount used. Bonding clays are strong plastic clays which develop strength rapidly, even when used in small amounts. They may be added to new or burned silica sand to form synthetic sand. Some sand producers now manufacture what is called "synthetic sand" by the addition of bonding clay to unbonded or low-bonded sand at the sand pits. As generally used in American foundry practice, however, the term synthetic sand covers any sand which is made in the foundry, as required, from materials selected and proportioned by the foundryman. A rebonded sand is one of which usefulness or life is prolonged by the addition of bonding clay.

A certain amount of burned sand is lost by adherence to castings. Common practice in making the synthetic sand is to add to the used sand enough clay bond to restore strength, and enough silica sand to maintain volume. Since this silica sand and the core sand used are the only new materials entering the sand they will eventually compose the entire heap or system. It is, therefore, essential to select a grain-size of this sand which will give the finish and permeability required. Synthetic sand has been used in steel-foundry practice for a great many years. Its use is so common that steel-foundrymen do not often speak of their mixtures as synthetic sands. The term, of course, describes such sand, but probably is used more often by iron-foundrymen in describing their combinations of bond clay and sands. The term clay-bond is a general one and may refer to fire-clay bonds, other plastic clays, bentonites or bentonitic clays. The reclamation and rebonding of used iron-foundry sands reached substantial volume in the United States between 1925 and 1930 and has increased steadily since. It now seems probable that a larger tonnage of castings is made annually in synthetic sand than is made in naturally-bonded sands.

Some objection has been raised to the term "synthetic sand" because the word "synthetic" might imply that the material was a cheaper and inferior substitute for naturally-bonded sands. It has been suggested that the sand be called "artificial sand" or "manufactured sand." The term "synthetic" has been in use so long that it will probably be continued. It is worth noting, however, that the product is used because the user believes it to be superior to, as well as cheaper than, the natural product. The writer has also read occasional references in the British technical Press to the effect that synthetic sands are widely used in the United States because there is a scarcity of good naturally-bonded sands. There are deposits of high-quality naturally-bonded sands in almost all parts of the United States, and they occur in enormous tonnages.

A synthetic sand may be made from all new unbonded sand and clay; from naturally-bonded sand and clay; from used moulding or core sand and clay, or from combinations of these various materials. The loss of sand on the castings must be replaced by daily additions of sand, which may be any of the above materials. The original sand will eventually be entirely replaced by the sand in the daily addition, resulting in a final mixture composed of the base material and bond. The final result is the same, therefore, whether a start is made with a completely new synthetic mix or whether rebonded old sand is the original material. The base sand may be a bonded sand, a low-bonded sand or an unbonded sand. An unbonded sand is preferable, since the clay in naturally-bonded sands is usually neither efficient nor refractory. The so-called bond in natural sands also frequently contains a substantial percentage of silt which adds little to strength, increases the amount of tempering water required, and reduces permeability and flowability. Some low-bonded sands are desirable, since the small amount of natural clay present provides a priming surface on the grains and substantially reduces the amount of bonding clay which must be added. Any final decision on base sand depends upon the delivered cost.

The base sand is examined for four properties: (1) grain size, shape and distribution; (2) minimum

* Paper contributed from the American Foundrymen's Association to the 38th annual conference of the Institute of British Foundrymen, held in Manchester on July 12, 1941. Abridged.

clay content; (3) refractory value; and (4) minimum expansion. The reasons for stipulating minimum clay content, minimum expansion and maximum refractory value are apparent. Some thought must be given to grain size, shape and distribution. While the type of bond clay used will have effect upon flowability and hence upon finish, it is true that fine finish is obtained only from fine-grained sands. While the type of clay will affect the permeability, it is still true that very high permeabilities are given only by comparatively coarse sands. For some years, a perfectly round grain was considered the ideal. It is now realised that such round grains require a comparatively higher amount of bonding material and cause greater difficulty from cutting and scabbing than do sub-angular grains, which are preferable. It has also been found that many sub-angular grained sands give satisfactory permeability, and may even give higher permeability than some round grained sands, despite all theories to the contrary. Burned core sand from oil-sand cores is an excellent material to rebond, as the grains have a rough surface and accept bond readily.

It was once thought that all fines should be eliminated and the sand grains concentrated upon as few screens as possible. It is now known that a certain percentage of fines is desirable, and that too heavy a concentration of grains on a few screens may give a sand having a pronounced tendency to rat-tail or buckle. This is due to the close packing of uniform grains in a sand of high flowability. When the silica grains expand, they break the mould face. A minor break causes a rat-tail; a larger break causes a buckle, and a still larger break causes a scab, although it is recognised that scabs are also caused by other factors. In the last case, the moving metal penetrates under the broken surface or removes a portion of the sand, replacing it with metal. These defects appear in maximum development in the cope of the mould. The fines in sand have much higher expansion than the coarser grains, yet their addition to the coarser grains reduces expansion difficulties. It has been said that the fines provide a cushion between the larger grains, but the author believes that their corrective action is due to the simple fact that they reduce flowability, thus increasing the distance between the coarser grains in the rammed mould face. This seems corroborated by the fact that a very small addition of cornflour is the best-known method of stopping these cope defects, short of changes in the sand grain distribution; cornflour reduces flowability faster than any other common moulding material.

The present trend is to seek the bulk of the material on three adjacent screens, with a few per cent. on possibly two more adjacent screens. Such a sand still gives high permeability in relation to its fineness, but the distribution is such as to reduce expansion difficulties. Some American foundries which use large quantities of oil-sand cores shake out as much as possible of the burned core sand into the sand systems and also return to the systems burned core sand which is carried away with the castings. It is then possible effectively to control the fineness of the system sand by varying the proportion of fine and coarse sand in their cores. This has been described more fully by Zirzow.*

In any moulding sand, foundrymen are interested principally in grain-size, green strength, dry strength, hot strength, permeability, durability, flowability, moisture required, resilience, expansion, contraction and sintering point. In selecting a naturally-bonded sand, there is the difficult problem of finding as many of these twelve properties as well developed as possible within an economical radius of location. In compounding a synthetic sand, only three properties must be found—grain size, permeability and expansion—as they are to be established in the base sands, and foundrymen can control the other nine properties to a substantial extent by their selection of clay bond to be used. Since there are many types of clays available, the problem of making a synthetic sand is considerably simpler than the problem of finding an equally satisfactory naturally-bonded sand.

Almost any kind of plastic clay will develop some binding strength. Special clays are used, because the clay should not only give green strength, but must also develop dry strength; have a high sintering point; the ability to mix rapidly; good durability; adequate strength at high temperatures; moderate contraction at high temperatures, and other special requirements for specific problems. The selection of the proper clay requires a knowledge of the essential properties of the general group of clays. Until a few years ago, there was considerable mystery even among clay producers themselves as to the reason for different results given by different clays. Recent work indicates that the mineral composition is the most important single factor in determining results. Thus, two clays each having the same percentage of clay substance might deliver approximately the same strength if kaolinite is the principal mineral in the clay substance of each. Two other clays, each having the same percentage of clay substance, might differ very sharply in bonding value if the principal mineral in one is kaolinite, while in the second it is a mixture of kaolinite and illite (beidellite). In addition, the strength of a clay bond is affected by the percentage of clay substance and the type of ion absorbed on the surface of the clay particles. The importance of the adsorbed ion is clearly indicated by Western and Southern bentonites. These materials, which differ radically in physical properties, are practically identical in particle size and mineral composition, but the Western deposit carries basic adsorbed ions, while the Southern carries acid adsorbed ions.

The high-quality clays in each group can be expected to give generally similar results, but there is, of course, a wide range in quality between the best and worst clays in each group. If refractory clays of low bonding power are eliminated, the currently available American bonding clays may be grouped into three classes, determined by their dominant mineral. These classes are given in Table I, herewith, together with their relative values for various properties in the production of synthetic sand. Comparison merely indicates the order from best to worst in each property.

Practically all of the refractory bond clays, such as fireclay and ball-clay, fall into the class of kaolinite clays, the most widely-used type of bond clay in the United States. Fireclays of excellent plasticity and refractory value are available in the United States and, as a result, the more costly ball-clays have not been able to justify entry into the market at their higher cost. The best of these fireclays have a fusion point of 1,675 deg. to 1,705 deg. C.; a clay content according to A.F.A. methods (fineness 0·02 mm.) of about 95 per

TABLE I.—*Relative Value of Various Types of Clays.*

—	Kaolinite.	Illite.	Montmorillonite.	
			Southern.	Western.
Highest green compression strength	4	3	1	2
Highest dry compression strength	2	3	4	1
Highest permeability	4	3	1	2
Least tempering water required	4	3	1	2
Highest sintering point	1	4	2	3
Greatest durability	1	3	4	2
Highest flowability	3	2	1	4
Best collapsibility	3	2	1	4
Highest resilience	2	3	4	1
Least contraction at 1,370 deg. C.	1	4	2	3
Fewest lumps in shake-out sand	3	2	1	4
Least intensive mixing effort required	4	2	1	3

TABLE II.—*Effect of Changes in Quantity of Clay and Water on Hot Strength.*

Bond or Combination.	Ohio Fireclay.	Ohio Fireclay.	Ohio Fireclay.
Per cent. bond	12	12	10
Per cent. moisture	4·0	3·5	3·3
Permeability	85	87	103
Green compression	8·5	10·5	8·7
Green deformation	0·019	0·017	0·015
Dry compression	71·5	52·0	47·5
Hot strength :—			
260 deg. C.	55	52	38
535 ,,	100	85	60
815 ,,	153	87	80
1,040 ,,	550	400	295
1,370 ,,	5	6	5

TABLE III.—*Hot Strength of Combinations of Bond Clays.*
Base sand, unbonded silica. Average grain fineness, 53.

Bond or combination.	S.B.	75 Per Cent. S.B.* 25 Per Cent. W.B.†	50 Per Cent. S.B. 50 Per Cent. W.B.	25 Per Cent. S.B. 75 Per Cent. W.B.	W.B.
Per cent. bond	4	3·8	4·3	4·8	5
Per cent. moisture	2·6	2·5	2·5	2·5	2·5
Permeability	178	180	171	160	167
Green compression	9·9	9·6	9·8	9·8	9·6
Green deformation	0·008	0·012	0·012	0·011	0·012
Dry compression	47·0	42·0	59·0	69·0	83·0
Hot strength :—					
260 deg. C.	21	31	36	43	75
535 ,,	35	42	53	55	74
815 ,,	30	70	160	175	195
1,040 ,,	25	65	90	95	490
1,370 ,,	3	4	5	4	8
Strength after cooling from 425 deg. C.	20	37	40	45	55

* S.B. = Southern bentonite. † W.B. = Western bentonite.

TABLE IV.—*Hot Strength of Combinations of Bond Clays.*
Base sand, unbonded silica. Average grain fineness, 53.

Bond or Combination.	O.F.C.	75 Per Cent. O.F.C.* 25 Per Cent. S.B.†	50 Per Cent. O.F.C. 50 Per Cent. S.B.	25 per cent. O.F.C. 75 Per Cent. S.B.	S.B.
Per cent. bond	12	9·25	6·5	5	4
Per cent. moisture	4·0	3·7	3·2	2·6	2·6
Permeability	85	118	139	167	178
Green compression	8·5	11·0	10·4	12·9	9·9
Green deformation	0·019	0·015	0·015	0·012	0·008
Dry compression	71·5	83·0	71·0	55·0	47·0
Hot strength :—					
260 deg. C.	55	54	35	40	21
535 ,,	100	59	50	48	35
815 ,,	153	100	62	30	30
1,040 ,,	550	450	238	85	25
1,370 ,,	5	5	5	4	3
Strength after cooling from 425 deg. C.	65	74	43	27	20

* O.F.C. = Ohio fireclay.
† S.B. = Southern bentonite.

TABLE V.—*Hot Strength of Combinations of Bond Clays.*
Base sand, unbonded silica. Average grain fineness, 53.

Bond or Combination.	W.B.	75 Per Cent. W.B.* 25 Per Cent. O.F.C.†	50 Per Cent. W.B. 50 Per Cent. O.F.C.	25 Per Cent. W.B. 75 Per Cent. O.F.C.	O.F.C.
Per cent. bond	5	5·2	6·8	8·5	10
Per cent. moisture	2·5	2·3	2·8	3·5	3·3
Permeability	167	162	154	116	103
Green compression	9·6	9·1	8·7	8·8	8·7
Green deformation	0·012	0·013	0·017	0·018	0·015
Dry compression	83·0	75·0	125·0	120·0	47·5
Hot strength :—					
260 deg. C.	75	40	65	116	38
535 ,,	74	65	100	160	60
815 ,,	195	120	240	250	80
1,040 ,,	490	560	830	1,000+	295
1,370 ,,	8	5	6	8	5
Strength after cooling from 425 deg. C.	55	61	89	110	—

* W.B. = Western bentonite.
† O.F.C. = Ohio fireclay.

TABLE VI.—HOT STRENGTH OF AUXILIARY BINDERS.
Base sand, unbonded silica. Average grain fineness, 53.

Bond or Combination.	S.B.*	4 per Cent. S.B.* 1 per Cent. C.F.†	5 per Cent. W.B.‡	5 per Cent. 1 per Cent. W.B. C.F.	4 per Cent. S.B. 2 per Cent. Pitch.	4 per cent. S.B. 1 per Cent. Resin.
Per cent. bond	4	—	5	—	—	—
Moisture	2·6	3·6	2·5	3·5	3·5	3·5
Permeability	178	138	167	152	110	128
Green compression	9·9	8·2	9·6	9·3	11·7	8·1
Green deformation	0·008	0·034	0·012	0·027	0·013	0·012
Dry compression	47·0	133·0	83·0	87·0	158·0	145·0
Hot strength :—						
260 deg. C.	21	85	75	63	67	42
535 ,,	35	48	74	50	144	45
815 ,,	30	45	195	105	102	41
1,040 ,,	25	65	490	280	100	96
1,370 ,,	3	3	8	6	6	3

* S.B. = Southern bentonite. † C.F. = Cornflour. ‡ W.B. = Western bentonite.

* "Sand Control in a Malleable Foundry," by E. C. Zirzow. *Trans. Amer. Foundrymen's Assn.*, vol. 45, page 134 (1937).

cent. and a clay content according to the pipette and hydrometer methods (fineness 0·005 mm.) of about 75 per cent. There is a greater difference in value between the good clays and poor clays of this class than between the class itself and any other class. Any statements about these clays or the clays in following classes will refer to the best of the individual groups.

A specially selected and prepared clay of this type is essential to good results. Since this type of clay is most refractory and gives the highest possible sintering point, it is particularly well-suited to heavy castings and to alloys which are melted at high temperatures. More of this clay must be used for any given strength than of the high-strength clays to be described later. Where very high permeability is required, it would, therefore, be preferable to use a higher-strength clay. An exception to this would be the case of the foundry which could not secure cheaply a base sand of the exact fineness required. In such case, the greater volume of this type of clay which would be used would tend to smooth up the surface of a coarser sand, giving the finish required. The kaolinite clays give moderate green strength; moderate dry strength; good flowability; the highest sintering point and lowest contraction at high temperatures of any type of clay. They are also the lowest in cost and have the highest durability.

Illite clays are not widely used in the United States, but they are included here because many naturally-bonded sands have illite as a major constituent in their clay content. There is wide variation in the value of various illites, but the best clays in this group have a finer grain size than the kaolinite clays and develop somewhat higher green strength. It is necessary to use a lesser amount, which results in higher permeability. They give good flowability and reasonably high sintering point. They have a moderate dry strength and a rather high contraction at high temperatures, but low durability as compared with the kaolinite clays. They may be considered an intermediate clay, with higher strength than the kaolinite clays but much lower strength than the montmorillonite clays. Their use depends upon comparative delivered costs at any particular location.

The montmorillonite clays used for bonding in the United States are the Western bentonites, produced principally in Wyoming, and the Southern bentonites, produced principally in Mississippi. Both types are carried in stock in the United Kingdom. These have the finest grain size of any bonding clays. They develop double the green strength of the best kaolinites. The Western bentonites swell when placed in water, while the Southern bentonites are non-swelling. The bentonites give the highest permeability of any clays and the highest or lowest dry and hot strengths, depending upon the type selected.

The most important recent American research work on sands has been on hot strengths and the most important recent development in practice has been the use of combinations of clays instead of a single clay.

Tables II, III, IV, V and VI, on page 145, show hot-strength behaviour; this information is important in choosing the single clay or the combination of clays to be used. Table II shows a rather startling increase in hot strength with only slight increases in clay and water content. This indicates that kaolinite clays have adequate hot strength for any job when properly handled. It may also indicate the source of some cracked castings in the malleable industry, since an over tempered batch of sand has far higher hot strength than the same sand properly tempered. Table III shows the gradual increase in hot strength from Southern bentonite, through combinations, to Western bentonite. Retained strength after cooling from 425 deg. C. indicates quantity of lumps to be expected in shake-out sand. A foundry might have washes and cuts due to the low hot strength of Southern bentonite or difficult shake out, lumpy sand and cracked castings due to the high hot strength of Western bentonite. A combination of the two may be made to yield the exact strength required.

Table IV shows the same progression from low to high hot strength when mixing Southern bentonite and Ohio fireclay. When difficulty is experienced with either low or high hot strength from a single bond, it is only common sense to use a combination that will give the hot strength required to stop cutting and washing and no more. This extends sand control into a hitherto untouched and frequently troublesome field. Table V shows that combinations of Ohio fireclay and Western bentonite, instead of giving hot strengths intermediate to the bonds used, gave a peak strength more than twice as high as either component. This could hardly have been predicted from low temperature dry-strength testing. Such combinations should have excellent application for heavy iron or steel castings. Table VI shows that additions of cereal binder (cornflour), pitch and resin sharply increase the dry strength of Southern bentonite, although the increase in hot strength is such as still to provide a highly collapsible sand. Such a sand should be desirable for steel castings which have a tendency to crack. It is interesting that the addition of cereal binder to Western bentonite did not appreciably increase dry strength, and caused a sharp decrease in hot strength. This indicates that steel foundrymen who have used such combination for increased strength have not benefited much in that respect, but have provided a more collapsible sand.

(To be continued.)

THE "WEBB" CONVEYOR CHAIN.

MESSRS. FRASER AND CHALMERS ENGINEERING WORKS, ERITH.

(For Description, see Opposite Page.)

FIG. 1. CHAIN ASSEMBLED.

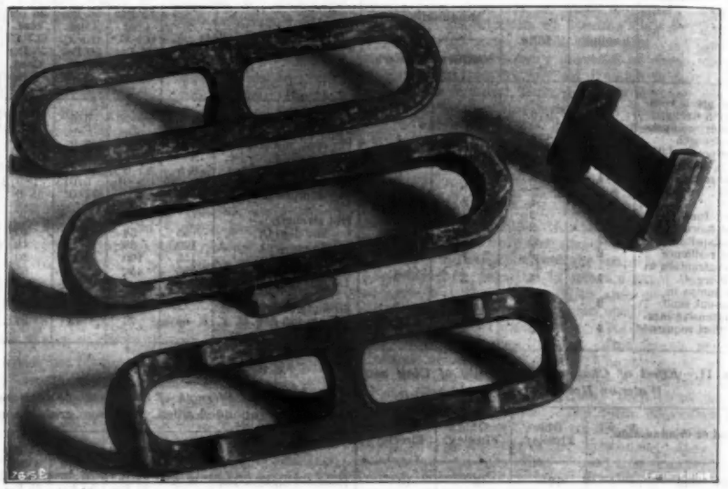


FIG. 2. SEPARATE COMPONENTS OF CHAIN.

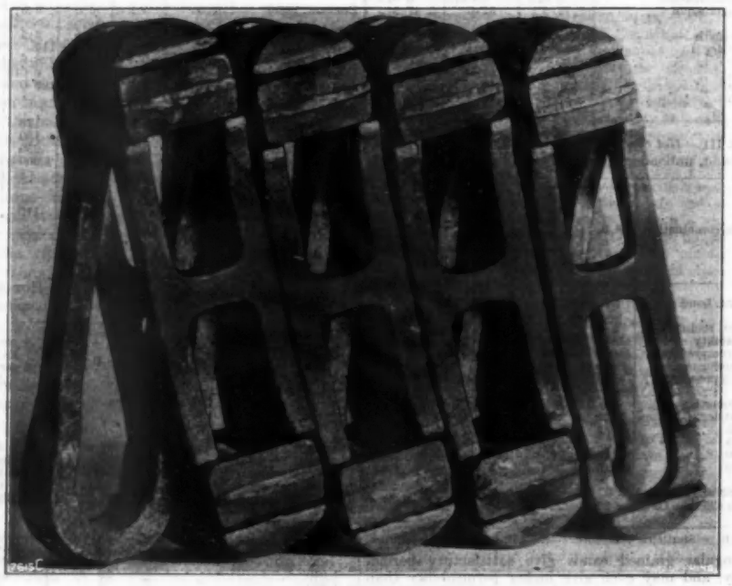
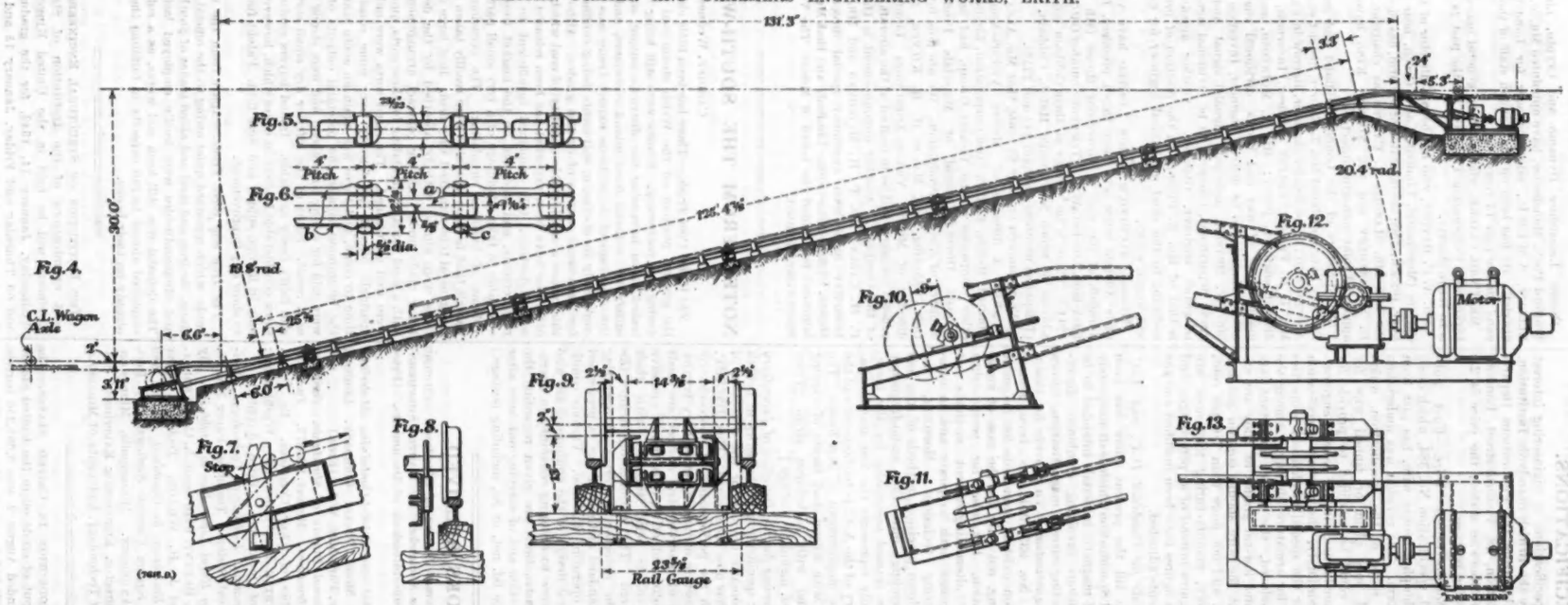


FIG. 3. CHAIN COLLAPSED FOR TRANSPORT.

FRANKLIN INSTITUTE.—The Committee on Science and Arts of the Franklin Institute, Philadelphia, Pennsylvania, U.S.A., has recommended that the award of the Howard N. Potts Medal be made to Mr. J. W. Beams, in recognition of his contributions to the problem of high-speed rotation and of his successful development of a wide variety of ultra-centrifuges. The Committee also recommend the award of the Edward Longstreth Medal jointly to Messrs. R. E. and E. V. Flanders for their work in connection with the development of screw-thread grinding machinery.

"WEBB" CONVEYOR CHAIN FOR TRUCK HAULAGE ON THE CENTRAL URUGUAYAN RAILWAY.

MESSRS. FRASER AND CHALMERS ENGINEERING WORKS, ERITH.



"WEBB" CONVEYOR SYSTEM FOR THE CENTRAL URUGUAYAN RAILWAY.

THE flexibility of the "Webb" chain type conveyor, manufactured by Messrs. Fraser and Chalmers Engineering Works, Erith, Kent, is obvious from its numerous applications. A new development of the system, however, is its use for the haulage of trucks for the transportation of ballast for the Central Uruguayan Railway. This system is illustrated by Figs. 1 to 13 on this and the opposite pages. The trucks are required to be moved a horizontal distance of about 130 ft. and a vertical height of 30 ft., *i.e.*, up an incline of about 1 in 4·3. With a full load of 2¼ tons of ballast each truck weighs approximately 3 tons, and they are handled at the rate of 160 trucks per hour, the capacity of the plant being thus 400 tons per hour. The gauge of the rails on which the trucks run is 23⅝ in. They are of the flat-bottomed type carried on longitudinal wooden sleepers, below which are transverse sleepers of 10 in. by 5 in. timber, pitched at 6 ft. Resting on the transverse sleepers and bolted to them are mild steel plates 6½ in. wide by ½ in. thick, to which are attached brackets carrying a pair of rolled steel channels one above the other. The "Webb" conveyor chains, of which there are a pair, are supported by idler rollers in these channels, and propel the trucks by means of projecting brackets which make contact with the truck axle. The chains are, of course, endless, with a forward propelling strand and an idle return strand.

The general arrangement of the installation is shown in Fig. 4 and the cross-section Fig. 9, and from these two views a good idea of the conveyor may be gained. Before describing the installation, however, we may deal with the construction of the conveyor chains themselves. The three photographs reproduced in Fig. 1 to 3 opposite, show a typical chain and Figs. 5 and 6 give the leading dimensions of that employed in this particular installation. A characteristic is that the four components of which each two links of the chain consist are all drop-forged high-carbon steel having a tensile strength of 85,000 lb. to 95,000 lb. per square inch, this material, in conjunction with the method of construction, providing a chain capable of withstanding shock loads and resistant to corrosive and abrasive action. The four components consist of the centre link indicated at *a* in Fig. 6, two side links indicated at *b*, and the connecting pin indicated at *c*. A pair of links of the chain is shown dismantled in Fig. 2. The plain oval link, known as the "keystone" or centre link is seen in the middle of the figure and above and below it are the two side links, the lower one as seen from the outside and the upper one as seen from the inside. It will be noticed from Fig. 6, that the connecting pin, being Tee-headed, is prevented from rotating in the side links by the head being held in slots. Smooth relative movement of the centre link and pin is provided for by machined surfaces of which that at the right-hand end of the link is clearly visible in Fig. 2. The centre link is "waisted," as will be clear from Fig. 6, the object of this construction being to allow the chain to be assembled or dismantled.

In the condition in which the chain is shown in Figs. 1, 5 and 6, *i.e.*, in tension, it is clear that the connecting pin cannot come out, but a little consideration will show that if the centre link is moved longitudinally until the "waisted" portion comes into line with the pin, the ends of the two side links concerned can be pushed in towards one another with the result that the Tee-heads of the pin are clear of the grooves in the side links. The pin can then be rotated axially through 90 deg., which permits the side links to be taken off, since the slots in these links, are longer than the width of the Tee-heads. Assembly and dismantling can be effected without the use of any tools, the only requirement being that the tension must be taken off the chain to a sufficient extent to permit the necessary longitudinal movement of one pair of links. At the same time, the links cannot come apart due to the accidental release of the tension seeing that deliberate lateral movement of a pair of links is involved in freeing a pin. The general design of the components is such as to eliminate all bending strains. The ultimate strength, the yield point and the life of the chain, the latter depending on the hardness of the bearing surfaces, can be greatly increased by suitable heat treatment during manufacture. In this particular installation the links have been heat-treated, stretch being reduced to a minimum and a high resistance to wear secured. Fig. 3 illustrates the flexibility of the "Webb" conveyor chain, though this actual collapsing of the links is only employed for packing for transport and storage.

The relation of the conveyor chains to the rails on which the trucks run is best seen in the cross-section, Fig. 9. The pair of chains are secured to open-ended boxes of steel channel section, to which are attached brackets projecting sufficiently above the rail surface to permit them to make contact with one or other of the wheel axles of the trucks. Movement of the chain then pushes the truck up the incline which has an angle to the horizontal of 13 deg. 20 min. 2 sec. The boxes are each carried on four rollers, in order to keep the pushing brackets rigid and in the installation now described there are 8 brackets on the length of the chain, 7 of these brackets having a pitch of 38 ft. and the remaining one a pitch of 39 ft. 4 in. As these pitches are of considerable length there would be an undesirable sag on the lengths of chain between the pushing boxes. The intermediate lengths of chain are, therefore, supported at intervals of about 32 in. by idler boxes having two rollers each. The chains and boxes are easily coupled together, though the exact method is not shown in Fig. 9. This feature of ease of attachment obtains, of course, with all applications of the "Webb" chain conveyor, as the boxes, suspension brackets, etc., can be bolted to the chains through the slots existing in the centre links and side links. In the present case the simplicity of attachment of the pushing boxes enables more trucks to be added readily should this be required.

The general lay-out of the installation will be clear from Fig. 4. The trucks engage and disengage automatically with the pushing brackets. The feeding rails are inclined downwards near the loading point of the chains so that the trucks run forward under gravity and enter the rails of the hauling line. The idler chain sprockets are depressed, as shown at the left of Fig. 4, so that, as a truck runs gently on to the horizontal

portion of the hauling line rails, one or other of the pushing brackets rises up and engages with an axle. The trucks are then hauled up the incline at a speed of 101·5 ft. per minute. At the delivery end of the haulage line a converse arrangement ensures the automatic run-off of the trucks. In view of the possibility of breakdown due to, say, an axle of a truck snapping, safety devices are fitted at intervals on the incline. The positions of these are indicated in Fig. 4 and more detailed views are given in Figs. 7 and 8. A pivoted pawl is fitted to the channels at each side, the pawls being weighted at their lower ends so that they normally lie in a vertical position as shown by full lines in Fig. 7. The forward tip is cut away so that the axle of a truck ascending the incline simply depresses the pawls, as shown by the chain-dotted lines, and no resistance is offered. But should a truck become detached from the chains and begin to run down the incline, the unbroken axle will eventually come into contact with the pawls, which resume the vertical position immediately after a truck has passed them in the forward direction, and force them backward to a position at right angles to the track as shown by dotted lines, further backward movement being prevented by stops. The pawl gear is so designed and spaced along the incline that a runaway truck cannot gain sufficient momentum to cause damage when it is brought to rest.

The lower, or tail, end of the chain track is shown in Figs. 10 and 11. The two sprockets are mounted in sliding bearings so that the chain can be correctly tensioned or slackened for removal, etc. The driving, or head, end is illustrated in Figs. 12 and 13. The drive is effected by a G.E.C. Witton motor of the totally-enclosed high-torque type, developing 30 h.p. and running at 725 r.p.m. The first transmission is through a totally-enclosed fan-cooled worm reduction gear and the second transmission through spur reduction gear with protective housing. The bearings in which the sprocket-wheel shaft is mounted are slightly adjustable on a slide to enable the exact relation between the gear wheel and pinion centres to be maintained. The method of supporting the steel channels carrying the pushing box and idler box rollers is shown in Fig. 9. The idler boxes are mounted so that side thrust is as low as possible and anti-friction bearings are fitted to both types of box.

Though the above description applies to a specific application of the "Webb" conveyor chain, it will be evident that the same principles can be adopted for other types of transport in which trucks are used. The use of the conveyor chain for erecting tables in motor-car works, overhead conveyors for factories and engineering works, etc., is too well known to call for particular comment.

ALUMINIUM WORKS IN AUSTRALIA.

A WORKS for the production of rolled plate, sheet and strip, forging billets, and extruded bar, rod, tubing and structural shapes of aluminium and aluminium alloys, has recently commenced operations at Granville, New South Wales. It is the property of Messrs. Australian Aluminium Company Proprietary, Limited, a firm established in February, 1939, and jointly owned by Messrs. The British Aluminium Company, Limited; Aluminium Limited of Canada; and The Electrolytic Zinc Company of Australasia, Limited. It is stated in *The Commonwealth Engineer* that virgin ingots of aluminium are imported from Canada and that all the alloys required are made up at Granville. In addition to wrought material, the new works also produces foundry casting ingots of various grades. The works includes a forge shop as well as rolling-mill and extrusion shops. The latter is equipped with a 3,000-ton extrusion press in which the forging billets, as well as extruded bars, rods, etc., are to be produced. The forging billets are to be used in the manufacture of aircraft propeller blades, aero-engine crankcases and pistons. The forging department, the construction and equipment of which is now practically completed, contains a 35,000-lb. compressed-air hammer. Another material to be produced in the new works is Alclad, which, as is well known, consists of sheets of Duralumin coated with pure aluminium. It was anticipated that the works would commence production in May, 1940, but difficulties in obtaining equipment led to a delay of some twelve months; finally, the necessary plant was obtained from the United States. After the conclusion of hostilities aluminium foil and other materials not made under war conditions will be produced.

WIDENING OF SHREWSBURY-HEREFORD ROAD.—We are informed that plans have been approved for the widening of the main Shrewsbury to Hereford-road, between Bayston Hill and Stapleton. The estimated cost is 7,789*l*.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Hard-Drawn Phosphor-Bronze Wire.—First published in July, 1930, specification No. 384, which deals with hard-drawn phosphor-bronze wire, has just been issued in revised form. The revision was undertaken in order that the scope of the specification, which previously covered only plain or tinned wire for armature binding, could be modified to provide for hard-drawn phosphor-bronze wire for general engineering purposes. Accordingly, the present specification does not now cover the special mechanical properties required primarily for armature binding. Among the modifications introduced, the more important are that tinned wire and low-tin grades of alloy are excluded. At present the wire should contain not less than 4·5 per cent. and not more than 7·0 per cent. of tin. Furthermore, manufacturing tolerances are given as definite figures instead of as percentages, and the tensile strength figures have been modified and the bend test requirements adjusted.

Magnetic Materials for Combined D.-C. and A.-C. Magnetisation.—Up till the present there has been no British Standard Specification which dealt adequately with the testing of magnetic materials intended to be used under conditions involving combined direct-current and alternating-current magnetisation, known as incremental magnetisation. To provide for this a new specification, No. 933-1941, has been issued. It is an advance on existing standards for magnetic testing by providing, not only for the case of incremental magnetisation, but also for permeability measurement by alternating-current methods at frequencies appropriate both to power and to communication-engineering technique. Moreover, the specification lays down precision methods of iron loss measurement extending into the audio-frequency range which, while framed essentially for the incremental case, actually represents the first standardisation in this country of the A.-C. potentiometer and the A.-C. bridge in the measurement of iron losses. The specification deals with silicon-steel sheets of varying silicon content and with nickel-iron strip. [Price 3*s.* 6*d.* net, or 3*s.* 9*d.* including postage.]

Photo-Electric Devices for the Detection of Incendiary Bombs.—A further specification in the series of British Standards for automatic devices for the detection of incendiary bombs has now been issued. This, BS/ARP. No. 60, deals with the performance of photo-electric devices for the detection of burning incendiary bombs. Three main types of photo-electric devices are dealt with, namely, photo-conductive cells, photo-emissive cells and photo-voltaic cells, together with their associated equipment. The specification defines the performance of the detector in terms of operating distance, and a standard method of test is prescribed to determine the operating distance. Various conditions for the general design of the equipment are also specified, with a view to ensuring reliability in operation, and some instructions are given regarding the methods of installation and of carrying out tests after installation. [Price 6*d.* net, or 8*d.* including postage.]

BOOKS RECEIVED.

United States National Bureau of Standards. Circular No. C430. *Glass Stopcocks.* By MARTIN SHEPHERD. Washington: Superintendent of Documents. [Price 10 cents.]

Properties of Nickel and Nickel-Containing Materials. London: The Mond Nickel Company, Limited, Grosvenor House, Park-lane, W.1. [Free.]

United States National Bureau of Standards. Building Materials and Structures. Report BMS73. *Indentation Characteristics of Floor Coverings.* By P. A. SIGLER and MYRTLE B. WOODWARD. Washington: Superintendent of Documents. [Price 10 cents.]

University of Minnesota. Institute of Technology. Engineering Experiment Station. Technical Paper No. 28. *Fuse Failures on Rural Lines Due to Lightning.* By PROFESSOR J. M. BRYANT, PROFESSOR L. C. CAVERLEY, M. NEWMAN and J. H. WILLOX. Technical Paper No. 29. *The Resistance to Combined Flexure and Compression of Square Concrete Sections.* By PROFESSOR PAUL ANDERSEN. Minneapolis, Minnesota, U.S.A.: The Director, Engineering Experiment Station, Institute of Technology, University of Minnesota.

PETROLEUM PRODUCTION IN UNITED STATES.—The average daily output of crude oil in the United States, during the week ended August 2, was 3,695,250 barrels, compared with 3,869,950 barrels in the preceding week.

PERSONAL.

Messrs. Lancashire Dynamo and Crypto, Limited, Trafford Park, Manchester, have appointed MR. M. G. R. ELLIOTT, A.M.I.E.E., sales manager for London and district. He has been on the London staff of the Company for the past 15 years.

MR. CYRIL CLARKE, who has been general manager of Birkenhead Corporation Transport for the past 28 years, is to retire shortly.

MR. A. P. HINTON, who has been a director of Messrs. Carters (Merchants), Limited, Lacey Green, near Aylesbury, Bucks., since the inception of the firm, has succeeded the late MR. HAROLD E. CARTER as chairman. MR. R. F. BRADLEY and MR. NORMAN KING have been appointed joint managing directors.

The directors of the London Midland and Scottish Railway have appointed MR. J. ELIOTT, district engineer, Abergavenny, to be district engineer, Barrow-in-Furness; MR. I. R. FRASER, district engineer, Inverness, to be district engineer, Perth; MR. A. MCINTOSH, assistant, maintenance of way and works, divisional engineer's office, Glasgow, to be district engineer, Inverness; and MR. W. BRYSON, assistant (signals), signal and telegraph department, Glasgow, to be divisional signal and telegraph engineer, Glasgow. Another appointment is that of MR. E. PUGSON to the position of principal assistant to the chief mechanical engineer for carriage and wagon works.

MESSRS. ALUMINIUM UNION LIMITED have vacated their Adelphi office and have taken premises, for the duration of the war, at Grosvenor House (8th Floor) Park-lane, London, W.1. (Telephone number GROsvenor 4941.) There is no change at their Cobham office, the address of which is Fairmile Hatch, Cobham, Surrey (Telephone numbers Cobham 249 and 2356).

We announced on page 68, *ante*, that MR. ALEXANDER DUNBAR, a director of Messrs. Vickers-Armstrongs Limited, Messrs. English Steel Corporation, Limited, and other companies of the Vickers Group, had been appointed Director-General of Materials Production, Ministry of Aircraft Production. We are now informed that, following this, MAJOR H. R. KILNER, M.C., a director of Messrs. Vickers-Armstrongs Limited, as general manager, will be in control of the aircraft section of the Company. Another announcement is that MR. P. H. CAREY, MR. P. H. MUIRHEAD and MR. S. G. HOMPHAY have been appointed special directors of Messrs. Vickers-Armstrongs Limited, and that Mr. P. H. Muirhead has joined the board of Messrs. The Variable Speed Gear, Limited.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—There has been little change in the general position on the Welsh steam-coal market during the past week. Efforts were still being concentrated upon increasing the district's output so as to satisfy the demand from inland customers, and under the Government restrictions export trade was almost completely in abeyance, shipments being confined to a few occasional cargoes of certain grades. Although by this means a considerable quantity of coal which would otherwise have been exported has been released for the war industries, this remained insufficient to satisfy requirements, and salesmen on the market were again only able to take advantage of a very small part of the volume of business circulating. The occasional odd parcels that became available were readily taken up and the general tone remained very firm. Best large descriptions were almost entirely absorbed by the deliveries being made under existing contract arrangements and, with a good demand circulating for these sorts, quotations were well maintained. The sized sorts were only very sparingly offered for delivery over some considerable time to come, and there was again an acute scarcity of the bituminous smalls, the potential outputs of which were sold for a long time ahead and were strong in tone as a result. Some of the inferior dry small sorts were still fairly freely available. Inland buyers continued to show considerable interest in cokes which, however, were only in limited supply and were firm. Patent fuel failed to show any improvement.

The Iron and Steel Trade.—Apart from the tinplate trade, which remained quiet owing to the official restrictions, the iron and steel and allied trades of South Wales and Monmouthshire were busily employed last week. The demand was still keen and works, as a rule, were employed almost to full capacity in fulfilling the orders already on their books.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—The next examinations of the Institution of Structural Engineers will be held in the United Kingdom on Wednesday, January 14, 1942, for the graduateship, and on Thursday and Friday, January 15 and 16, for the associate-membership.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Larger quantities of iron and steel are being absorbed by firms engaged exclusively on the production of war material. Business in other types of products is being well maintained, though the output of some types is governed by the amount of steel allowed under the rationing system. A highly satisfactory position obtains in the raw and semi-finished steelmaking branches. Production is at a high level, and as more plant is brought into use further headway will be made. Business in basic-steel billets is brisk, and the call for acid steel is considerably greater than it was a year ago. Bar iron is also in better demand. The scrap market has bright features; supplies are stated to be ample. Imports of pig iron, hematites and foundry iron are well up to recent standard. The heavy machinery and engineering branches are active, there being an accumulation of commercial orders. Railway rolling stock is in strong request. Among the products in demand are wheels, axles, springs, tyres, and buffers. Overseas requirements are naturally less than they were a year ago, but a steady trade is being maintained with the Dominions and Colonies, and a few orders have been received from South American countries. An increasing trade is being done in steelworks and ironworks machinery and related equipment. Rolling-mill plant of all types is on order, and there is an active demand for lathes and other machine tools. Sheffield works are supplying large quantities of crushing plant used for mining, quarrying and roadmaking. The Dominions and Colonies are good customers for steel balls for crushing purposes, washing and refining equipment, and dredger parts. Makers of electrical steel and similar high-class materials are supplying increased tonnages to centres manufacturing electrical plant, agricultural machinery and parts, and engines of all types. Hollow forgings and boiler drums, some of record size and weight, are being delivered from this area to various parts of the country. Boiler makers are exceptionally busy. Firms engaged exclusively in the production of high-efficiency steels are increasing their outputs. Research work is being continued with the object of producing still more efficient steels; some works have extended their research laboratories considerably during the past year. Messrs. Spear and Jackson, Limited, will shortly bring into use a new steel laboratory.

South Yorkshire Coal Trade.—There is an increasing demand for all types of fuel, and a definite tendency for production to be increased at some collieries. Industrial coal is in heavy demand by steel and iron works, where stocks are being built up. Steam coal is active, and locomotive coal is moving freely. Smalls and slacks are in demand chiefly by electricity and gas undertakings. The house coal market is more buoyant. Foundry and furnace coke are progressive.

CHANGES IN EUROPEAN INTERNATIONAL TRAIN SERVICES.—It is stated in *The Railway Gazette* that the Baltic train-ferry service, between Sassnitz, in Northern Germany, and Trelleborg, in Southern Sweden, has been suspended. On the other hand, rail traffic between France and Switzerland has been resumed, trains running between Geneva and Bellegarde.

VALVE VOLTMETERS.—Messrs. Salford Electrical Instruments, Limited, Peel Works, Silk-street, Salford, Lancs., have sent us some particulars of two new valve voltmeters recently designed and put into production by them. The first, known as type BW. 211, has been introduced for general laboratory purposes and is capable of measuring voltages at frequencies ranging from 20 cycles to 200 megacycles per second. It is suitable for use on 200-volt to 250-volt mains without adjustment, and has five voltage ranges from zero to 1·5, 5·0, 15, 50 and 150, respectively. Its accuracy is within ± 2 per cent. of the full-scale reading on all ranges. The signal to be measured is applied to a diode rectifier which has a high load resistance, so that the input condenser is charged to a negative voltage almost equal to the peak voltage of the signal. This voltage is passed on to a direct-current amplifier which has a degenerative action. The detecting diode is contained in a small head attached to the main unit by a flexible cable, thus enabling it to be taken directly to the point at which the signal is to be measured. The second instrument, known as type BW. 218, is intended to supply the requirements of those who need a simple valve voltmeter to operate over a limited frequency range. It has three ranges, from zero to 5, 25 and 100 volts, respectively, and is battery-operated and entirely self-contained. The instrument has a long edgewise scale with a knife-edge pointer, the pivots being normally in a vertical direction. It is fitted with a special low-loss ceramic high-frequency terminal and with a removable finger button to enable the 3-volt torch battery, which operates the instrument, to be inserted. Both types are provided with substantial walnut cases.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The brief holiday suspension of operations at certain works has enabled the much needed repairs and renewals of plant to be carried out. While the output of some commodities has overtaken commitments there is no prospect of any surplus tonnage and regulations under the control of distribution scheme are unlikely to be relaxed. At the same time, recent shortening of delivery periods and the assurances of essential supplies of iron and steel to firms engaged directly on work of national importance have checked forward buying, consumers realising that present conditions no longer render it necessary for them to cover their prospective increasing requirements.

Cleveland Iron Trade.—Cleveland pig is still scarce and there seems no likelihood of an early increase in output, but the supply of foundry iron from other producing areas is ample and consumers are taking advantage of the freer issue of delivery licences to accumulate stocks. While most of the iron passing into use is from the Midlands, adequate parcels of certain qualities of pig are regularly reaching this district from other sources. Second hands are dealing with larger tonnages, but the transactions are still mainly direct between producers and consumers. The official values of Cleveland pig are ruled by No. 3 description at 128*s.*, delivered within the Teeside zone.

Basic Iron.—Producers of basic iron are keeping the output at a level which fully covers the requirements of their own steelworks but provides no saleable tonnage and the quotation remains nominal at 120*s.* 6*d.*

Hematite.—As much use as possible is being made of refined iron and steel scrap in place of hematite, the supply of which is somewhat short. Rationing of consumers under the control of distribution scheme is strictly enforced and only essential quantities are allocated to users with priority delivery claims. The stabilised prices are based on No. 1 grade of hematite at 138*s.* 6*d.* delivered to North of England buyers.

Foreign Ore.—Imports of most kinds of ore are sufficient for the current needs of users, but the difficulty of obtaining descriptions for the manufacture of hematite has not yet been reduced.

Blast-Furnace Coke.—Durham blast-furnace coke is plentiful and the local consumption heavy, but little effort is being made to put through new business. Holders have extensive running contracts and are disinclined to add to their commitments, while users have covered their requirements as far ahead as they consider necessary. Good medium qualities are quoted at 36*s.* 9*d.*

Manufactured Iron and Steel.—There are good stocks of semi-finished iron and steel at the re-rolling mills and deliveries of local makes are satisfactory. Finished ironworks are turning out large quantities of heavy commodities, but have only moderate orders for light descriptions of material. Manufacturers of steel sheets and certain kinds of structural steel are less actively employed than has been the case for some time but are still producing a substantial tonnage, while makers of ship, tank and boiler plates are obliged to keep their plant running at full capacity in order to cope with the demand.

Scrap.—Merchants are able to deliver adequate parcels of light iron and steel scrap, but the demand for heavy grades continues unabated.

MEMENTO OF THE STOCKTON AND DARLINGTON RAILWAY FOR THE ARGENTINE.—According to *Modern Transport*, the General Purposes Committee of Darlington Corporation has recommended to the Council that a suitable memento of the Stockton and Darlington Railway should be sent to the non-British staff of the Argentine railways as a token of thanks for their gift of a mobile kitchen for the use of Darlington's Civil Defence services.

MEMORIAL TO LORD AUSTIN.—A fund to provide a memorial to the late Lord Austin has been inaugurated by Lord Nuffield with a personal contribution of 1,000*l.* A similar sum was immediately promised by the Austin Motor Company, Limited. While the ultimate form of the memorial must depend, to some extent, on the amount subscribed, it is hoped that the bulk of the money will be allocated to an endowment fund to be administered by the Motor and Cycle Trades Benevolent Fund. Lord Nuffield believes that, not only those in the motor trade and associated industries, will wish to contribute to the fund, but also numerous persons who were introduced to motoring for the first time by the "Baby Austin"—possibly Lord Austin's greatest and most personal achievement. Contributions, which will be gratefully acknowledged, should be addressed personally to The Viscount Nuffield, Morris Motors, Limited, Cowley, Oxford.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, August 30, 2 p.m., Neville Hall, Newcastle-upon-Tyne, 1. General Meeting, Formal business, including the election of officers and council for the ensuing year.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Little change has occurred in the Scottish steel trade during the past week and all the works are actively employed. Shipbuilders are very busy and there is a steady flow of specifications for plates and sections; boilermakers are also fully occupied and their demands account for a considerable tonnage. There are numerous inquiries for special high-grade steels. Structural steel is moving freely and there is a steady demand for the lighter grades of steel material. Makers of black steel sheets still have well-filled order books, but have overtaken most of their arrears and are now able to execute orders for the usual gauges promptly. Supplies of raw materials are satisfactory and every endeavour is being made to collect as much scrap as possible in order to keep plant in full production. Prices are steady and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—Conditions in the West of Scotland malleable-iron trade are rather dull at present, and although there is a good deal of work on the books new business is not very plentiful. Supplies of scrap are somewhat scarce and makers would welcome a larger tonnage than has been coming forward recently. The re-rollers of steel bars, who have a number of important contracts on hand, are in a position to execute speedily a limited amount of new business of an urgent nature. The stocks of semies now held are quite satisfactory. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—There is a heavy demand in the Scottish pig-iron trade, especially for hematite, which is urgently needed by the steelmakers. The furnaces are in full blast and the maximum output is being obtained. Good stocks of imported iron ore have been accumulated and reserves of native ores are also being utilised. Although the demand for foundry grades of iron is not very heavy, a fair amount of business is going through. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

USE OF PEAT AS LOCOMOTIVE FUEL.—Experiments have recently been carried out on the Great Northern Railway of Ireland in which mixtures of peat and coal have been used as locomotive fuels. Similar experiments have also been made on the Great Southern of Ireland Railway, and on both lines, certain services have been run by locomotives consuming this fuel. The change has necessitated some structural alterations to the locomotives, including the hooding over of the tenders.

WOVEN BELTINGS IN WAR-TIME.—A timely section of a brochure issued by Messrs. J. H. Fenner and Company, Limited, Hull, deals with the methods recommended for the de-contamination, after exposure to war gases, of the firm's patented "Z" dressed belting, the rubber and cotton of which this belting is made readily absorbing blister gases. No doubt the methods will apply to other makes of woven belting and the recommendations are, therefore likely to be of more general interest; they have been approved by the Ministry of Home Security. The brochure also includes general instructions for the fitting and maintenance of woven belting and useful information is given regarding horse-power ratings, pulley diameters and so forth, together with notes on fastenings, the object of the latter being to show how the consumption of metal belt lacings and fasteners can be reduced under present conditions. Only a limited number of copies are available and it may be noted that Messrs. Fenner's address for all correspondence, for the present is "The Grange," Whitcliffe-road, Cleckheaton, Yorks.

200-TONS DEADWEIGHT REINFORCED-CONCRETE BARGES.

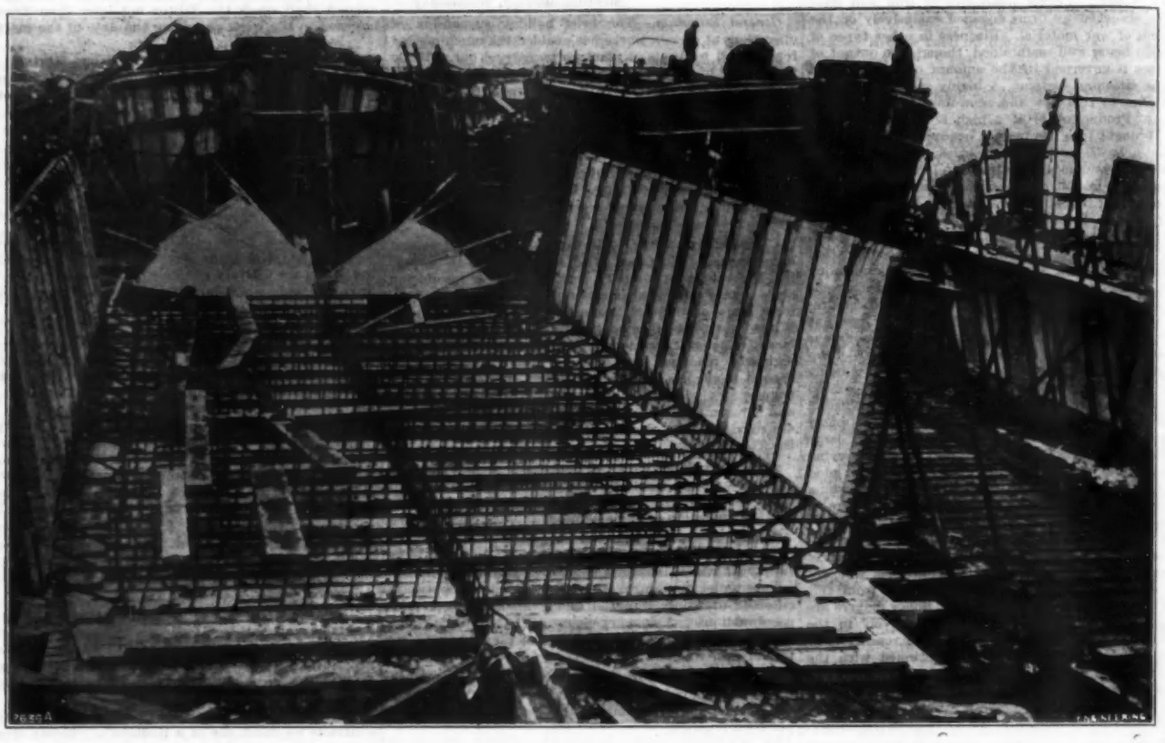


FIG. 1.

200-TON REINFORCED-CONCRETE BARGES.

ON page 133 of last week's issue of ENGINEERING, we referred to the 200-tons deadweight reinforced-concrete barges, many of them of precast-slab construction, which have been built during the past twelve months or so to the order of the Admiralty. The brief particulars then given can now be supplemented by the accompanying illustrations, Figs. 1 and 2, which show, respectively, the method of construction and the finished barge, ready for launching, and provided with the necessary wooden fenders and equipment of deck fittings. It will be seen that the type illustrated does not differ greatly from the conventional steel Thames barge; although it may be observed that even so unpromising an underwater form as that shown can be improved to an appreciable extent by careful design, as was demonstrated by the tests, in the William Froude Tank, described in a paper read in 1930 by Dr. G. S. Baker and Miss E. M. Keary before the Institution of Naval Architects. There is reason to suppose that the experimental work there summarised had some influence on the eventual design of the new concrete barges.

The decision of the Admiralty to turn once again to reinforced concrete as a shipbuilding material caused considerable surprise when their intention was realised, rather more than a year ago, for the concrete-ship programme of the last war was by no means an unqualified success. That scheme was mooted in 1917, though it was not adopted until the end of that year. Possibly it was launched on too ambitious a scale, and at so late a stage in the war that the man-power then available was of an even lower grade of average skill than was contemplated by the sponsors of the proposal. At all events, according to the *Official History of the War*, only one 1,000-ton barge had been completed by the end of October, 1918, although eight small shipyards were either laid out or adapted for the purpose, and over 200 orders had been placed. Some of the vessels were subsequently completed, and several tugs and at least one concrete coaster, the Armistice, eventually passed into private ownership and were operated commercially with a certain amount of success. They were not notably popular, however, especially among the repairers into whose hands they came periodically for survey and overhaul. There seems little reason to suppose that the present revival of the reinforced-concrete barge will outlast the period of the war, or that this method of construction will ever be able to compete successfully with steel under normal conditions.

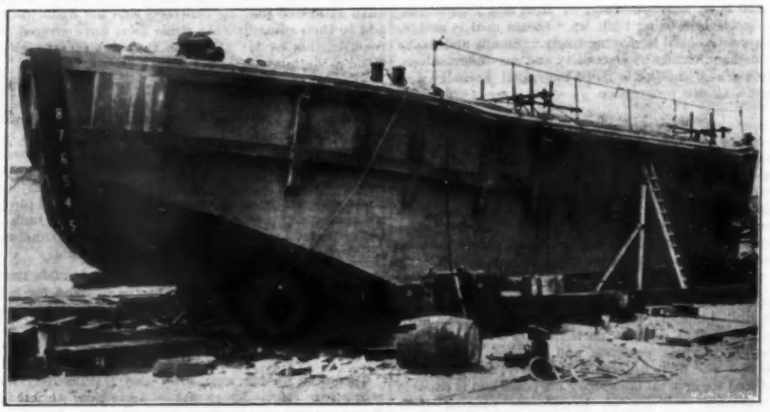


FIG. 2.

UNITED STATES COLLIERY INDUSTRY.—During the week ended August 2, the bituminous coal production in the United States averaged 1,750,000 tons daily, against 1,793,000 tons in the preceding week and 1,379,000 tons in the corresponding week of 1940.

AMERICAN EXHIBITION OF THE CHEMICAL INDUSTRIES.—The 18th Exposition of Chemical Industries is to be held in the Grand Central Palace, New York, from December 1 to 6. The success of the exhibition appears to be assured by the fact that practically the whole of the available space has already been taken up. Dr. M. C. Whitaker, vice-president of the American Cyanamid Company, is chairman of the Advisory Committee, which includes Messrs. L. H. Backeland, J. V. N. Dorr, H. E. Howe (Editor, *Industrial and Engineering Chemistry*), W. L. Evans (President, American Chemical Society), and E. R. Weidlein (Director, Mellon Institute).

REGULATIONS FOR MOTOR VEHICLES DRAWING TRAILERS.—The Minister of War Transport proposes to make two changes in the regulations dealing with vehicles drawing trailers. In the first place, all vehicles up to 30 ft. in length will be permitted to draw trailers. Hitherto no vehicle exceeding 26 ft. in length has been allowed to draw a trailer. This concession will be subject to the requirement that the combination of vehicle, drawbar and trailer shall not exceed 60 ft. in length. The concession will not apply to articulated vehicles. Secondly, the maximum laden weight of a combination of vehicle and trailer will be 32 tons instead of 22 tons as at present, on condition that the trailer is equipped with power-assisted brakes which can be operated by the driver of the drawing vehicle. These brakes must not be of a type which are rendered ineffective if the engine is not running, and a warning device will be required to acquaint the driver of any impending failure in the vacuum or pressure system. These concessions are being made on the advice of the Inland Transport War Council with the object of increasing the carrying capacity of vehicles during the present emergency; they will be discontinued at the end of the war.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, AUGUST 22, 1941.

VOL. 152. No. 3945.

THE EMPLOYMENT OF ENGINEERS.

THE after-effects of the war of 1914-1918 covered a period of world-wide economic stringency, with widespread unemployment which was not confined to wage-earners. It fell with severity on the administrative and black-coated staffs of manufacturing firms, which were forced to a drastic reduction in overhead expenses. Professional engineers of all grades suffered in the storm, frequently finding themselves in a worse position than wage-earners who were protected by unemployment payments and trade-union benefits. It may be that the future will not show a repetition of that period of stress. Hopes for a better age are high and in their recent joint declaration the President of the United States and the Prime Minister of His Majesty's Government state that they desire to bring about "improved labour standards, economic advancement and social security" and to ensure "that all men in all lands may live out their lives in freedom from fear and want."

It is the fashion at the moment adversely to criticise the period which followed the previous war, and to suggest that the hopes which ushered in that era were vain. We are rather vaguely promised something better after the present conflict. It is natural that the stress of the time should result in strained emotions, leading to exaggerated hopes and overstatements. Before the storm broke, we were told that another world war, reinforced by the noxious power of twenty years of scientific progress, would destroy civilisation. The same thing was said in 1913, but, as Sir William Beveridge pointed out at the Aslib lunch in 1939, civilisation is of tougher fibre than that. So far from anyone in this country now thinking that the war will destroy civilisation, all believe that at the end it will be established on a firmer foundation. Despite current criticism of the period which followed Versailles, it actually marked an important stage in social progress. It may be that the elements of evil which have again disturbed the world were not dealt with so effectively as they might have been, but this did not prevent fundamental improvement in the social structure of the country, and a definite rise in the standard of living of the mass of the population.

The hopes expressed in the joint declaration of President Roosevelt and Mr. Churchill are not likely to be realised in their literal terms in any measurable period of time, but the spirit which animates them will operate, with increasing effectiveness, to bring nearer the age which they foreshadow. Wars, civil disturbances, bad faith, and evil ambitions hamper progress towards social betterment, but do not stop it. The road is chequered, but is not broken. It would be absurd to pretend, however, that in any material sense the war can help mankind forward. It may stiffen determination and renew hopes, but the destruction which it is causing is pure material loss. Mr. Keynes has estimated that the wrecking of houses, churches and other structures in this country does not represent more than a year's work for the building industry. If this is correct, our scarred towns should begin to look a little more normal within a relatively short time after the conclusion of peace, but this will not affect the fact that that year's work will in effect be wasted. With no destruction, it might have been spent in the re-housing and other town improvements, which, although they have never ceased to progress, still lag behind the stage which the social conscience has reached.

It may be that the reconstruction of almost every type with which we shall be faced will be sufficient to absorb all available energies and time until normal life is restored, but that does not mean that such progress as can be made will start from the point that had been reached in 1939. The effects of the debt we are now accumulating will cover the lifetime of the youngest person now living. True wealth may lie in the work or energies of a people, but the effect of that wealth on progress must be conditioned by the extraneous load it is carrying. The performance of a steamship is far from the best possible if an important proportion of the output of the engine is dissipated by barnacles adhering to the bottom. It would appear that there should be a call for full power output and occupation for every ready hand. This, however, did not prove to be the case in the economic blizzard which followed the last war. Unemployment, which ranged from the shop labourer to the chief engineer, swept through all countries, and matters were only approaching normal again shortly before the new disturbance arose. A more highly developed social conscience and the elaboration of governmental machinery may prevent similar causes having similar effects in the time that lies ahead. There is an uninformed notion in the public mind that they will, and the implications of the social revolution which such activities must represent are overlooked or ignored.

The future social structure of this country is too large a subject to deal with in a single article, but an illustration of the possible effects of war is afforded by conditions in the United States. The economic collapse which set in about 1929 travelled from west to east and first broke in that country. Unemployment rose to a level previously undreamt of, and ultimately resulted in the introduction of legislation which has modified the whole basis of government activity. As in this country, the effects of the slump were not confined to manual labour but spread to the administrative and technical staffs. Valuable information concerning its incidence on professional engineers has been collected by the Bureau of Labor Statistics of the United States Department of Labor and is presented in a report entitled *Employment and Earnings in the Engineering Profession* 1929 *to* 1934. The basis on which "a professional engineer" has been defined, for the purpose of the report, is that he shall be a member of a recognised engineering society.

As will be clear from its title, the report covers the question of earnings as well as employment. The former aspect of the matter we cannot deal with at the moment, but it may be noted that the average earnings of engineers declined by one-third between 1929 and 1934. This was a natural effect of a period of financial stress. Most engineers in this country had similar experience. The broad results shown by the inquiry on unemployment are

that while, owing to the output of engineering graduates, the number of engineers increased by 25 per cent., in the period covered, the number of jobs increased by only 4·4 per cent. At the worst stage, about one-tenth of the professional engineers were unemployed, and, during the period, approximately one-third of the total number were unemployed at one time or another. Three-fifths of the graduates of the years 1930 to 1934 had not been able to make a start in their profession by the end of 1934. One natural result of this state of affairs was that the proportion of engineers engaged in non-engineering occupations rose from 6·3 per cent. in 1929 to 14·1 per cent. in 1934.

It is of great sociological importance to note that the increase of 4·4 per cent. in the total number of jobs available was entirely due to increase in public employment. In private firms, employment decreased by 11·8 per cent. from 1929 to 1932 and, although there was some increase from 1932 to 1934, was still 8·2 per cent. below the 1929 level at the end of 1934. The increase shown between 1932 and 1934 was only half the corresponding increase in employment by public authorities. Over the full period, there was an increase of 46·8 per cent. in public employment against a decrease of 8·2 per cent. in private, relative to the numbers employed, the rate of increase of public employment being five times as great as that shown by private employment. The striking contrast illustrated by these figures has been brought about by a complete change in the trend of governmental activity in the United States. The change, usually described as the New Deal, was forced by economic conditions, rather than deliberately adopted as the path of progress.

The late Lord Stamp, in a Royal Institution discourse a few years ago, pointed out that the New Deal comprehended two different forms of activity. One was of a temporary nature and was introduced to deal with an emergency; the other was of more permanent type and represented a definite constitutional change. In the organisation of affairs in this country, public control and ownership was extended over a much wider field than in the United States, and many things which are revolutionary in that country would be taken as a matter of course here. In a sense, many innovations introduced under the New Deal were already established custom with us, so that, even had we been inclined, much that was done under its auspices to temper the bitter wind could not have been copied in this country. Although no sweeping changes in public activity were introduced here to help us to weather the storm, various measures were taken to assist the labour market. They were, in general, of Lord Stamp's first form, and were designed as temporary reliefs to unemployment. Many took the form of road-construction schemes. They were in all cases mainly designed to absorb unskilled or semi-skilled labour. Certainly no consideration was given to the interests of professional engineers.

The time is not yet when the social activities of this country in the next post-war period can be usefully discussed in detail. It is to be hoped, however, if another lean period must be faced, that the serious effects on the professional classes, such as are illustrated by this American report, will not be ignored. With our long tradition of labour legislation, there is a tendency to focus attention on the operative classes, to the exclusion of others. The last post-war measures, thinking only of manual labour, placed constructional works in the hands of public authorities, and the carrying out of many was marked by great inefficiency and waste. It is to be hoped that this procedure will not be followed in the future. Large-scale works will be called for even if there is no unemployment, and not only will they be carried out most efficiently and cheaply by utilising existing organisations, but, by so doing, engineers and other technical men will be kept in employment. Apart from the fact that the conditions which are shown to have existed in the United States must have represented a great deal of private distress, the loss to the country is greater when it fails to utilise the ability of a trained man then when an unskilled labourer is temporarily unemployed.

TWO POINTS.

Of the eight points, comprising the joint declaration of British-American peace aims which followed the meeting of President Roosevelt and Mr. Winston Churchill "somewhere at sea" last week, two appear to have a particular bearing on the task of re-establishing an ordered civilisation when active hostilities cease. They are the fourth and the fifth. The first and second are statements of a policy which, in fact, hardly needed to be stated, unless for the benefit of such countries—if they exist at all—as are unable to detect the falsity of German propaganda or to perceive the entire absence of desire for "aggrandisement, territorial or other" on the part of both Great Britain and the United States. The third point, the affirmation of the right of all peoples to choose their own form of government, is a matter of the internal policy of individual nations so long as the form of government actually chosen is not one which is primarily devised to facilitate interference with the affairs of other nations. The sixth, seventh and eighth points are fundamentally designed to prevent a recurrence of world warfare; properly implemented, they should afford every facility for the restoration of normal social and industrial life, but their function is protective rather than actively constructive.

The fourth and fifth points, on the other hand, are obviously intended to represent a working basis for future international trade relations and industrial conditions, and as such are much more the intimate concern of all engaged in manufacturing industry and in commerce. The fourth point declares that the respective Governments "will endeavour, with due respect for their existing obligations, to further enjoyment by all States, great or small, victor or vanquished, of access on equal terms, to the trade and to the raw materials of the world which are needed for their economic prosperity." The fifth point, which may be regarded as a necessary counterpart of the fourth, expresses their "desire to bring about the fullest collaboration between all nations in the economic field, with the object of securing for all improved labour standards, economic advancement, and social security."

As broad principles, these are wholly admirable. They avoid the cardinal error of promising, in a fervour of uncritical idealism, so much more than can be guaranteed of performance that the actual advances which may be achieved may appear negligible by comparison with the unattained ideal; while they set a goal which is not impracticably remote, given the free collaboration of all concerned, and sufficient time for it to become effective. President Roosevelt and Mr. Churchill are realists, as they have demonstrated on many occasions, and can be under no delusions regarding the magnitude of the task that is involved in effecting the changes in world policy which they agree to be desirable; but there are many whose eagerness to bring about the Millenium is liable to blind them to the difficulties and to the fact that time—a great deal of time—will be necessary if the aspirations of the eight points are to be realised. Evolution is usually a slow process, because it must depend on educative influences which do not lend themselves to artificial acceleration, except to a very limited extent.

With comparatively few exceptions, the raw materials of the world have always been freely accessible to those who were prepared to treat for them on honourable terms; of this, there can be no more telling proof than the success with which the Germans themselves have exploited the principle of "peaceful penetration" in past years, not only in semi-developed countries such as Russia but within the British Empire also. If this process is not to continue in the future, it is essential that those countries which are favourably circumstanced in the matter of natural resources should themselves undertake to develop those resources for the benefit of mankind; for the full fruition of the principle of the fourth point cannot be achieved if any such country is permitted to adopt a dog-in-the-manger policy, neither exploiting its own natural advantages nor allowing others to do so. Nations have as varied characteristics as individuals, and are by no means equally endowed with the qualities and capabilities which are requisite in making the most of their own natural possibilities. To some extent, improved educational facilities are overcoming this disability, as representative students from the relatively backward nations are taking home and putting into practice the knowledge they have acquired in the better-equipped centres of learning; but the effects of climate and environment cannot be entirely overcome, and the peoples whose national characteristic is indolence will never be able to compete on equal terms with those whose instinct is to be up and doing. Equality of opportunity is a practicable ideal enough, given mutual goodwill; but equality of accomplishment could only be ensured by enforcing upon all alike a least common factor of performance and forbidding all individual attempts to improve upon it. This, unfortunately, appears to be the principle upon which many trade-union policies have been based, and it still finds powerful adherents.

A more intelligent and receptive attitude of mind in this respect seems to be an essential preliminary to the effective realisation of the desire expressed in the fifth point, to secure for all improved labour standards, economic advancement, and social security. In many things it is an advantage to "think internationally," but we are not convinced that the question of "improved labour standards" is one of them. Much has been made of the policy initiated by the present Minister of Labour, of bringing Indian mechanics to this country to work under British conditions, with the intent that they shall eventually return to India as prophets of a new industrial order, conversant with all the workings of British trade-union machinery. An instructive commentary on this innovation is provided in a recent editorial article in the *Journal* of the Association of Engineers, Calcutta—a society of Indian technicians, of which many members, including the editor of the *Journal*, are graduates of British universities.

"The introduction of trade unionism into India," the writer observes, "is a matter that is looked upon with suspicion as much by the general public as by employers in India. Trade unionism is generally regarded as synonymous with a conspiracy to strike for the purpose of enforcing demands for higher wages. . . . Movements for the raising of labour rates do not obtain the same sympathy in India as they do in Great Britain and other great industrial countries. . . . Workmen in India are in general not entirely dependent upon industry for their earnings, as they have agriculture to fall back upon. For this reason labour rates can be maintained at a somewhat lower level than in other countries. It has therefore become the custom to look upon labour leaders as mere agitators who somehow obtain personal benefit by inducing labourers to imagine grievances where they formerly felt none, and to make demands for rises in wages, which they had been satisfied with as long as there was no agitation. . . . In India, where factory rules have been introduced and the interests of labour are watched by local Governments, the reported scheme to introduce trade unionism is looked upon with apprehension as a political movement that might result in further disadvantage to Indian industry."

It has been necessary to omit some portions of the article, which is too long to quote in full, but the extract given may serve as an indication of the unwisdom of attempting to impose Western ideas upon Eastern industrial conditions, without due regard to other factors which may bear upon the local situation. Even if an absolute equality of remuneration could be ensured between all industrial nations, this would not mean that their products would compete on equal terms in the world's markets, so that an equal measure of social security (which must depend on a substantially uniform and constantly maintained volume of trade) would not necessarily be better assured than under the conditions that were regarded as normal before the war. The ultimate solution is not obvious, but it seems unlikely to result from the imposition of artificial standards, irrespective of local conditions. The flow of trade, like the flow of electric current, must always require some difference of potential.

NOTES.

STATE BURSARIES IN SCIENCE.

THE Board of Education has established a scheme of State bursaries for boys and girls who have reached a certain educational standard, in order to meet the demands of the Services and of industry for technical officers. The bursaries will be tenable at universities and at certain technical colleges. There is at present a pressing demand for men and women for work in various branches of wireless telegraphy and telephony for which physics is, of course, an essential subject. Other candidates will be required for positions needing qualifications in engineering and in chemistry. The bursaries will cover tuition fees and maintenance allowances to meet the full cost of residence at the university or college at which the awards are held, and they will be awarded without regard to the circumstances of the candidates' parents. The qualifying standard will be a "pass" in physics, chemistry, or mathematics in certain combinations in the Higher-Certificate examinations, and the Board of Education will shortly offer bursaries to those candidates who have reached the necessary standard in the recently held Higher Certificate examinations. Furthermore, applications are also to be accepted from persons who have passed the London intermediate B.Sc. degree examination in the appropriate subjects. It is emphasised that applications cannot, as a rule, be entertained from pupils who left school before the end of last term and are now in employment; neither will students at present attending universities and colleges be considered eligible. Moreover, unless the applicant possesses exceptional qualifications, the minimum age for candidates is 18. It is expected that some of the holders of State bursaries may be able to qualify for a university degree before they are required for national service; others, however, will be asked to relinquish their university course at the end of a year's studies. With regard to these latter, the Board has promised that, in suitable cases, they will be considered for such assistance as may be necessary to enable them to complete their degree courses after the conclusion of hostilities. Eligible candidates are requested to send to the Secretary, Board of Education, Branksome Dene Hotel, Bournemouth, their name, age, address, and school, together with particulars regarding the university or college to which they would prefer to be allocated, and the course, namely, physics with radio; electrical engineering with radio; chemistry or engineering, which they would prefer to take. From the above particulars it may be concluded that the scheme is one of the most far-reaching yet put forward by the Board of Education and it will doubtless attract a considerable number of suitable candidates.

REGISTRATION OF BUILDERS AND CONTRACTORS.

IN pursuance of his plan to organise the building and contracting industries, the Minister of Works and Buildings has made a regulation (Defence Regulation 56AB—S.R. and O. 1941, No. 1038) requiring all building and civil-engineering contractors to register their names and addresses, with brief particulars of the nature of their business, not later than September 1. Forms for this purpose are obtainable from any local office of the Ministry of Labour and, when completed, must be sent to the Secretary, Ministry of Works and Buildings, Sanctuary-buildings, 18, Great Smith-street, London, S.W.1. It is emphasised that this regulation does not apply to employees, but it does apply to all employers or firms engaged in public works contracting, constructional engineering, the installation of heating, ventilating and electrical equipment in buildings, and in general building, plumbing, glazing, painting and decorating, plastering, joinery and carpentry in buildings, etc. All local authorities and public utility undertakings which have building or civil engineering departments must register; but private firms, not primarily in these categories, which maintain a buildings maintenance branch, need not do so unless outside work of that kind is carried on for other firms. Before granting a certificate of registration, the Ministry must be satisfied that the terms and conditions of employment jointly agreed in the industries, and conditions regarding Sunday work and hours of employment which the Minister may direct, will be observed by the firm or contractor; but a provisional certificate may be granted before these requirements have been determined. In filling in the application form, the builder or contractor undertakes to observe these conditions. Certificates will be issued as soon as possible after the receipt of applications; and it is pointed out that anyone carrying on business after October 1 in the industries concerned, without a certificate, will be liable on conviction to a fine or imprisonment, or both. If the conditions abovementioned are not observed after the certificate has been issued, it may be withdrawn; and, to ascertain that they are being observed, it is provided that "the authorised representative of the Minister may, at any time, inspect an undertaking or any of its activities." The Minister may also require, by Order, any persons employing labour in any of the activities described, "whether or not they are required to register under the Regulation, (*a*) to keep such records, (*b*) to make such returns, (*c*) to produce such documents and furnish such information, in regard to such activities, as he may direct." Public notice will be given of any such Order. Apparently it is not known how many concerns or individual businesses will be affected by the Regulation; one estimate puts the figure as high as 80,000. The official statement claims that the registration is an important step in the organisation of these industries for maximum war effort, though, on the face of it, the main provisions appear to have been dictated more by political than purely productive considerations.

AMERICAN SHIPBUILDING.

The figures given by our American correspondent, in the "Engineering Notes" on page 155 of this issue, regarding the work in hand in the shipyards of the United States, confirm how rapidly the emergency shipbuilding programme is taking effective shape, and show that the claims made by Admiral Emory S. Land for the building capacity of the United States yards is in a fair way to being substantiated. Admiral Land was speaking at the launch, on August 16, of the Ocean Vanguard, the first of the sixty 10,000-ton cargo steamers under construction by subsidiaries of the Todd Corporation to the order of the British Merchant Shipping Commission. The vessel is being built at Richmond, California, in the new shipyard (which was illustrated on page 90 of our issue of August 1) where the naming ceremony was performed by the wife of Admiral Land. There was not the slightest doubt, said Admiral Land, that the ships that were being built by Great Britain and the United States would eventually win the war, just as ships had won every international war. America was prepared to build ships at twice the rate that was achieved in the last war. Already the industry was months, or even years, ahead of that effort, and was aiming to produce more than 1,200 merchant ships by the end of 1943. As our description of the Richmond yard indicated, welding is being extensively employed in the construction of these British vessels. On some of the American contracts it is being used to an even greater extent, and a report from Pascagoula, Mississippi, states that the Ingalls Shipbuilding Corporation launched, in July, a passenger vessel which is being welded throughout. This ship, the African Comet, is 489 ft. long and will have a displacement of 18,500 tons. From the laying of the keel to the date of launching, it is stated, she was on the stocks for exactly 51 weeks; but, as the message does not indicate how far she was completed at the time of launching, it is not possible to compare this rate of construction with that of a riveted ship of equal size. The African Comet is said to be the first all-welded passenger ship to be built in the United States, which is possibly true; but the further claim, that she is the first all-welded ship in the world, is quite incorrect. That distinction belongs to the motor coaster Fullagar, built at Birkenhead during the last war; and it will be recalled that a paper was read before the Institution of Naval Architects in 1939, describing the sloop, H.M.S. Seagull, which also was welded throughout. Neither of these vessels, however, approached the size of the African Comet, the construction of which must have presented some difficult problems in overcoming heat distortion during fabrication.

THE AIR FERRY DISASTERS.

The accident to a trans-oceanic ferry aircraft, which flew into a hillside on Sunday, August 10, shortly after taking off, and was destroyed with the loss of the whole of the 22 passengers and crew, was generally accepted as a misfortune of the kind that can hardly be avoided entirely, however rigid the precautions taken; but the similar disaster to a second aircraft, under apparently identical conditions, only five days later, has multiplied the concern manifold. The second crash occurred on August 14, and the aircraft appears to have been in the air for an even shorter period than in the former instance. It began to lose height while still over the aerodrome, on the edge of which it collided with a raised road, went through a fence and finally crashed in a field, where it caught fire and was completely destroyed. As in the former case, the entire complement of 22 were killed, so that no first-hand evidence is available to assist the investigation which was immediately instituted under the superintendence of Captain Harold Balfour, Under-Secretary of State for Air, and the Air Ministry's Chief Inspector of Accidents. Pending the result of the inquiry, there can be no point in multiplying theories, but it is to be hoped that some official statement will be made, notwithstanding war conditions, to allay the anxiety caused by the occurrence of two disasters, in so short a space of time, to a service which had operated previously with notable freedom from serious mishaps. The second crash was especially deplorable from the standpoint of Anglo-American co-operation, in that one of the passengers killed was Mr. Arthur Blaikie Purvis, chairman of the British Supply Council in North America and head of the British Purchasing Commission. Mr. Purvis, who was 51 years old, had had a remarkable career. A Londoner by birth, but of Scottish descent, he was a boy of 13 at Tottenham Grammar School when the death of his father obliged him to seek employment, which he found in a London merchant's office. At the age of 20, he obtained a post with Nobel's Explosives Company, Limited, where his qualities of leadership brought rapid promotion. By the time that he was 24, he had visited South Africa and South America on behalf of his firm, and was in charge of their New York office, where he was responsible, throughout the war of 1914-18, for the purchase of materials required by the British Government for the manufacture of explosives. After the war, and when he had recovered from the serious breakdown in health which his exceptional efforts had occasioned, he remained in America as director of various firms, and finally went to Canada, in 1924, as president of the firm then known as Canadian Explosives, Limited, which he subsequently reorganised as Canadian Industries, Limited. He also acted as chairman of the National Employment Commission set up by the Canadian Government, and was a governor of McGill University and a trustee member of the Royal Institute for the Advancement of Learning. On the outbreak of war in 1939, he was appointed chairman of the Anglo-French Board for purchasing supplies in the United States, and, after the collapse of France last year, continued as Director-General of the British Purchasing Commission and chairman of the British Supply Council. In this dual capacity, he had been responsible in a large measure for obtaining the supplies of munitions of all kinds, purchased from the United States, and for arranging for the additional supplies provided by the United States Government under the Lend-Lease Act.

LLOYD'S REGISTER SCHOLARSHIP.—The scholarship in marine engineering offered annually by Lloyd's Register of Shipping on the results of an examination held under the auspices of the Institute of Marine Engineers, has been awarded to Mr. John Adam, who is a student of the Royal Technical College, Glasgow, and an apprentice draughtsman with Messrs. David Rowan and Company, Limited. The scholarship is tenable for three years at a British university.

LETTER TO THE EDITOR.

THE TIDE-GENERATING FORCES.

To the Editor of Engineering.

Sir,—Referring to Dr. Doodson's article in your issue of May 23, on page 414, I have always understood that the general theory of the tides, accepted with some modifications up to the present time, was that arrived at after Newton's discovery of the law of gravitation. According to this theory, owing to lunar attraction, the water of the ocean at any point directly under the moon was drawn up and formed a tidal "hump." At the same time at the corresponding point on the other side of the earth the water bulged up in a similar "hump" owing to the fact that the moon, attracting the body of the earth more strongly than the surface water there, drew the earth away from the water. Owing to the earth's rotation these two "tidal humps" moved round the earth, thus causing the tides. This is a general statement which I need not elaborate.

Dr. Doodson's theory is apparently a new one; how far it has been discussed by other scientists I do not know. The chief differences as compared with the usual theory are: (1) that, instead of merely considering the general action of the attractive forces of the moon (and sun) on the earth and sea at different places, it is necessary to consider the variations in the attractive forces at different points; (2) only the horizontal component of the tractive force can operate in tidal movements. I have always been sceptical about the accepted explanation of the second tidal hump produced on the other side of the earth from the moon, and am therefore inclined to accept Dr. Doodson's theory that the horizontal component of the attractive force at different points is the one which produces the tides.

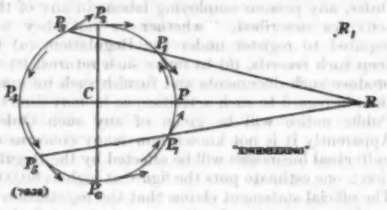
It is a little difficult to follow Dr. Doodson in the mathematical reasoning leading to the establishment of the formula for the horizontal component of the tractive force. He does not give the reasoning in detail, but leaves the reader, for the most part, to work it out for himself, merely indicating certain quantities which may be regarded as negligible. The formula for the horizontal component at which he arrives is

$$X = \frac{3}{2} g \frac{M}{E} \left(\frac{a}{r}\right)^3 \sin 2A.$$

I could accept this as correct were it not that Dr. Doodson holds that the horizontal tractive force is determined not simply as the horizontal component of the force $\frac{K}{PR^2}$ acting at P and along P R (see Dr. Doodson's Fig. 1), but as the difference between this horizontal component and the horizontal component of the force $\frac{K}{CR^2}$ which acts at C, but which must be supposed to be transferred so as to act at P along a line parallel to C R. I cannot understand this; I should have thought that the tractive force X required would be simply the horizontal component of the force $\frac{K}{PR^2}$ acting at P. Dr. Doodson justifies his reasoning by saying that "Clearly, we ought to compare all forces everywhere with those at the centre of the earth . . . so that, if we transfer the force at C to P and take components of the two forces, we can then take the difference between the components."

As I say, I cannot understand this, and am doubtful, therefore, if he has arrived at the correct (approximate) formula for the value of X. Now the formula at which he has arrived contains the factor sin 2A, and since sin 2A = 0 when A is any multiple of 90 deg., he naturally arrives at the conclusion not only that the force X is zero immediately under the moon and away from it (*i.e.*, on the other side of the earth), but also that "it is zero on the great circle at right angles to the line of centres of earth and moon." It is obvious, of course, that the force X is zero "immediately under the moon and away from it," but surely not for points on the great circle referred to. If in Fig. 1, for example, C P were perpendicular to C R, then R P along which the tractive force would act would be practically tangential to the surface. I think, therefore, that Dr. Doodson has not arrived at the correct formula. I would suggest the following as a very general statement of the way in which the horizontal tractive forces operate to produce the tidal humps:—

In the accompanying diagram let C represent the earth's centre; R the moon; P, P_1, P_2, etc., the successive positions of a point or place on the earth's surface as the earth rotates; R_1 the moon's new position when P has made one complete rotation; the arrows inside the circumference indicate the direction of the earth's rotation, while the arrows attached to P_1, P_2, etc., indicate the direction of the horizontal tractive force at these points. R would actually be very much farther from C were the diagram to scale; therefore lines to places such as P_1 and P_2 from the scale position of R would be but slightly inclined. At P directly under the moon there is a tidal hump and the horizontal tractive force is zero. As P moves round



through P_1 to P_2 the horizontal tractive force increases to a maximum near P_2, but it acts in a direction opposite to that of rotation. Therefore the tractive force tends to pull the hump back. Near P_2 the hump has been completely reduced and there is low tide. Between the positions P_2 and P_4 the tractive force still acts in a direction opposite to rotation, but is gradually reduced to zero at P_4. This tractive force backwards gradually produces another hump which reaches its height at P_4. Then from P_4 to P_6 the tractive force, reaching a maximum near P_5, acts in the same direction as that of rotation, and this will reduce the (backward) hump which was formed at P_4, so that there is low tide near P_6. Then from P_6 to P the tractive force, passing from a maximum at P_6 to zero at P, but acting in the same direction as that of rotation, produces a hump at P, which however does not reach its height till P is directly under the moon in its new position at R_1.

Yours faithfully,

J. M. L.

August 11, 1941.

OBITUARY.

MAJOR-GENERAL SIR SYDNEY CROOKSHANK, R.E.

We regret to record the death of Major-General Sir Sydney D'Aguilar Crookshank, which occurred on August 17, at Fleet, Hampshire. After many years in civil employment under the Indian Government, Sir Sydney filled, with conspicuous success, the position of director-general of transportation on the Western Front from March, 1918, until May, 1919. He was the second son of the late Colonel A. C. W. Crookshank, C.B., Indian Army, and was born on June 3, 1870. Entering the Royal Engineers in 1889, he was selected for continuous service in India. From 1891 to 1893 he was engaged on surveys and construction works for the Indian State Railways and afterwards was given charge of a number of building works in the United Provinces. In 1895 he was employed as assistant field engineer on the lines of communication of the Chitral Relief Force and from 1898 until 1907 was in charge of the Kumaon and Lucknow Divisions of the Public Works Department. From 1908 to 1910 he was engaged on the construction of several works, including the bridge over the Gumpti River and the Canning College at Lucknow. For his work in connection with the Royal Durbar at Delhi in 1911 he was made an M.V.O.

In 1912 he was created a C.I.E., and from this time until 1914 served as superintendent engineer in connection with the construction of the new capital at Delhi. He went to France in the autumn of 1914, and after serving in various capacities and gaining the D.S.O. at Vimy Ridge in 1916, received the appointment of director-general of transportation, which gave him the supervision of all railways, light railways, and road and inland water transport at the Front. He was mentioned seven times in dispatches, created a C.B. in 1918, and a K.C.M.G. in 1919. On returning to India after the war, he was appointed Secretary to the Government of India Public Works Department, and, in 1923, consulting engineer to the Government of India. In June, 1925, he was made chief engineer of the Southern Command, at home, and retired with the honorary rank of Major-General in 1927. In 1936 he was honoured with the appointment of Colonel Commandant, R.E.

AMERICAN SOCIETY FOR TESTING MATERIALS.

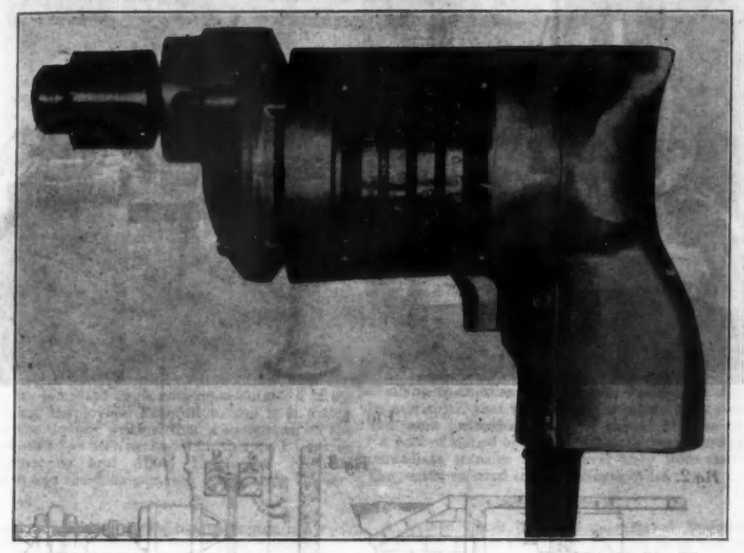
Widespread interest in the field of engineering materials, particularly in the development of knowledge regarding these materials and in the standardisation of specifications and tests, was evident at the forty-fourth annual meeting of the American Society for Testing Materials held in Chicago, from June 23 to 27 last. During the week, the sixth exhibition of testing apparatus also took place. The registered attendance of members, committee members and guests at the Chicago meeting exceeded that of any other. The total, which was 1,553, was higher than that at New York in 1937, the previous best-attended meeting, and was greater by 125 than that of the 1940 Atlantic City meeting. There were also more committee meetings held than in any previous annual meeting. These totalled upwards of 250. Progress in the matter of standardisation was indicated by the fact that some 70 new specifications and tests were published for the first time, many covering quality requirements and procedures for testing important engineering materials and products. Moreover, there were 17 technical sessions at which 115 scientific papers and reports were presented, and all the sessions and committee meetings were well attended.

The address of the retiring President, Dr. W. M. Barr, entitled "Speed, Specifications and Safety," and a talk by Mr. J. H. Van Deventer, President and Editor of *The Iron Age*, were features of the opening session. Dr. Barr, chief chemical and metallurgical engineer of the Union Pacific Railroad Company, who has been concerned for 25 years with the quality, inspection, and analysis of materials, briefly described some of the important changes which had taken place in recent years in the conceptions of the degree of strength required of various products employed in railway equipment and track. He pointed out that all the many improvements in materials which had been evolved by research activities had necessitated the constant revision of specifications and the drawing up of many new ones. This had demanded co-operative work between representatives of producers and consumers, and within the Society technical committees had devoted much time to the study and discussion of the specifications. Associated with all these researches were the names of many prominent members of the Society. In conclusion, he stated that, in the existing national emergency and in the years ahead, the safety of the nation and the future success of its whole economic life would be determined by the work of the research scientist and the production engineer. They had performed invaluable services in the past four decades, and now, and in the years to come, the specifications and the research work of the American Society for Testing Materials would have a prominent place in solving the many grave problems that would be encountered—problems which must be successfully solved if the American nation and way of life were to survive. The services of the Society had been offered to the United States Government and the members were proud that such services had already been accepted and were being used to advantage. Whatever might be the political or economic beliefs of any individual member, it could be stated with assurance that the members of the Society would not be found wanting and would put forth every effort to speed up production in the interests of national safety.

Mr. Van Deventer, in discussing "Mobilising Materials for Defence," referred to the state of industrial civilisation which had been enjoyed for about 70 years, and compared this with the 7,000 years of recorded history. He then said that man should definitely bear in mind that the knowledge which he did not yet possess far outweighed the store of facts which he had accumulated and this must be taken into account when facing the heavy task of preparing for defence or for war. He expressed the belief that the war would

ELECTRIC HAND DRILL.

MESSRS. THE CONSOLIDATED PNEUMATIC TOOL COMPANY, LIMITED, FRASERBURGH.



probably be won by something new—something new in the management of materials that would enable the United States to bring to bear more effectively in production her overwhelming superiority in natural resources. He then reviewed the various metals and other products, and the probable calls on the supplies of these materials, and concluded that the war was essentially a competition between nations in the production and utilisation of materials. As the result of the constant co-operative studies and research carried out by the Society, America had been placed at the forefront of world's peace-time industrial production, and now, in these critical times, the members had assembled to place the nation in the same outstanding position for defence.

Dr. H. L. Fisher, who delivered the Sixteenth Edgar Marburg Lecture, chose as his subject "Natural and Synthetic Rubbers." He pointed out in his concluding remarks that vulcanised synthetic rubber compounds were superior to natural rubber compounds in that they showed a better resistance to the action of oils and fats, both vegetable and mineral, and to the action of many solvents, and were more resistant to heat. Furthermore, synthetic rubbers aged better on storage and in sunlight, showed a better resistance to the action of ozone and oxygen, had a lower permeability to gases and a lower water absorption value; they also offered greater resistance to the action of many corrosive chemicals. On the other hand, natural rubber still superior, compared with all the synthetic rubbers now available, in the matter of elasticity and resilience, low heat generation through hysteresis, extensibility, and resistance to stiffening at low temperatures.

As already stated in our columns, the 1941 award of the Charles B. Dudley Medal was made to Professor C. W. MacGregor, during the course of the meeting. He is associate professor of applied mechanics at the Massachusetts Institute of Technology, and he was awarded the Medal for his paper on "The Tension Test," presented at the 1940 Annual Meeting of the Society, which paper was considered an outstanding contribution to research in engineering materials. The Medal, of which the present award is the fifteenth, commemorates the name of the first President of the Society. It is presented to the authors of meritorious contributions to the proceedings and is intended to stimulate research in engineering materials. Among the new officers installed at the meeting were Mr. G. E. F. Lundell, head of the Chemistry Division, National Bureau of Standards, who succeeds Dr. W. M. Barr as President of the Society. Mr. Dean Harvey, materials engineer, engineering laboratories and standards department, Westinghouse Electric and Manufacturing Company, was elected vice-president and will serve with Professor H. J. Ball, professor of textile engineering, Lowell Textile Institute, who was elected vice-president in 1940. Among other announcements, it was stated that the 1942 Annual Meeting of the Society would be held in Atlantic City, New Jersey, from June 22 to 26.

ELECTRIC HAND DRILLS.

THE compact electric hand drill illustrated on this page is one form of a new universal drill recently introduced by Messrs. The Consolidated Pneumatic Tool Company, Limited, whose temporary address is Fraserburgh, Aberdeenshire. The phrase "one form" refers to the fact that the drill is also made with a different gearcase from that shown, housing double-reduction gearing when low spindle speeds down to 500 r.p.m. are required for drilling such materials as stainless steel. The armature in all the patterns runs at a free speed of 18,500 r.p.m., and this, in the standard high-speed patterns, drives the spindle through single-reduction gearing at a speed of either 3,500 r.p.m. or 5,000 r.p.m. in pattern No. 806, and of 2,500 r.p.m. in pattern No. 808. The double reduction gear for the slow speeds referred to above is applicable to pattern No. 806 only. The external form and dimensions of the body are the same in all patterns. As regards capacity the speeds in pattern No. 806, make the drill suitable for holes $\frac{1}{16}$ in. in diameter, and in pattern No. 808 for holes $\frac{1}{4}$ in. in diameter, both in steel.

The drills with single-reduction gearing weigh only 3 lb. 6 oz. and have an overall length of $7\frac{5}{8}$ in. and a spindle offset of $\frac{3}{4}$ in. These characteristics render the drill particularly convenient for use in restricted spaces, but it should be understood that, in order to secure them, no sacrifice of adequate mechanical construction has been made. The housing consists of a cylindrical body which contains the stator and armature, and of a pistol grip handle containing the switch and trigger. The gearcase is in two parts, viz., an inner part projecting into the main casing and an outer cover. The armature spindle is mounted in ball bearings carried at the switch end in an extension of the main casing so that rough usage of the handle will not disturb the bearing alignment. At the driving end the ball bearing is carried in the inner part of the gearcase which also carries one of the bearings for the driving spindle. The other bearing of this spindle is carried in the gearcase cover. All are readily accessible and all the outer races are bedded in steel inserts cast in the aluminium casings. The transmission gears have helical teeth to ensure quietness in running.

The motor is of the universal type with the usual series characteristics. There is a separate holder of varnished fibre for each brush, held firmly in position. The switch is easily accessible and cable renewals can be made without disturbing it. The ventilating arrangements are unconventional, the air intakes being at the end of the handle where they will not pick up swarf and dirt and are not covered by the operator's hand. The fan is situated on the armature spindle between the end of the armature and the main bearing in the gearcase. The air is discharged through the annular slots seen to the left of the illustration, and thus keeps the gearcase cool while having a tendency to disperse swarf. The drill can be adapted for use as a screwdriver or nut-runner.

ENGINEERING NOTES FROM THE UNITED STATES.

THE most important shipbuilding programme since the 1914-1918 World War is now well in hand in the United States. On July 1, shipbuilders had under construction or on order 893 merchant ships, totalling 5,906,795 gross tons. Of this total, 634 ships of 2,692,300 gross tons, will be steam propelled, 76 vessels, of 452,000 tons, will be turbo-electric, and 101 ships will have Diesel engines. How the remaining 80 will be propelled has not been made known. By far the greater number of the vessels are for the United States Maritime Commission. Only 86 ships, not including the 60 emergency freighters under construction in the Todd yards for the British Purchasing Commission, are for private accounts, and these total but 799,860 gross tons. Those for the Maritime Commission include 83 tankers of 894,000 gross tons and an aggregate capacity of 11,399,000 barrels. This work alone will cost 223,623,500 dols. All the tankers will be delivered between August, 1941, and the end of December, 1943. Besides the 893 merchant ships under construction on July 1, the United States Navy had 359 vessels in hand at that time. Of this latter total, 199 are destroyers. In addition, the Maritime Commission is preparing to place orders for 566 additional ships, in accordance with a request by President Roosevelt, in the middle of July, for Congress to vote a further 1,246,650,000 dols. for such work.

Machine tool shipments in the United States for June, 1941, increased to 63,400,000 dols., as compared with 60,800,000 dols. for May of this year and 34,000,000 dols. for June, 1940. This was announced on July 18 by the National Machine Tool Builders' Association, which stated also that the entire production of the industry was being supplied for either defence work or as aid to Great Britain. The machine tool industry has practically doubled its rate of production within the last twelve months. Nine-five per cent. of the industry's personnel are employed by companies which are working two or three shifts; sub-contracting is steadily increasing, and programmes for training new employees are in full swing. Shipments are expected to continue to mount steadily and, according to present indications, the industry should exceed its anticipated total production of 750,000,000 dols. during 1941. It was reported, too, on July 15, that the American steel industry was operating at 97·2 per cent. of capacity and that the output has been above 90 per cent. since August, 1940. This is the longest period on record that output has been maintained at so high a rate as 90 per cent. capacity, the last long spell at or above that rate being for six months in 1929. Plans are going forward for increasing the capacity of the industry by ten million tons annually.

Defence work continues to be the principal feature of all Federal activities. Early in July, Congress passed a bill providing 95,000,000 dols. for the improvement of existing civilian airports of strategic military value and for the construction of new landing fields considered to be of possible value in war. This appropriation is in addition to the 89,000,000 dols. made available during the past few months for the same purpose. Under the programme, which is independent of the large number of Army and Navy air bases built for strictly military purposes, 399 airports will be improved. The Federal Government funds will be spent only for construction purposes and in buying equipment; the local government or agencies provide the land required. A few days after the new airport appropriation had been passed, the Federal Government reported that between January 1 and July 1, 1941, a total of 75 new civilian airports of strategic military value had been improved with Federal funds. This compares with 51 such airports built during the entire year 1940 and brings to 2,277 the total number of airports of all classes approved by the United States Civil Aeronautics Authority, which is the Federal body controlling the nation's aviation fields. Present approved ports include 1,935 city or municipally owned, 795 commercially operated, 282 ports operated for both municipal and commercial purposes, 27 Navy fields, 74 Army ports, 41 miscellaneous Government fields, and 23 private landing fields. Of the total, 690 airports are either fully or partially equipped for night landings. New seaplane bases made available since January 1, 1941, total thirty-six.

The American construction industry reported, for the week ending July 10, the greatest total of new construction awarded in any one week in the nation's history. In all, new heavy construction to the value of 298,718,000 dols. was contracted for. This total does not include private residential building, waterworks, and waterways projects costing less than 15,000 dols., industrial buildings valued at less than 25,000 dols., or expected to total less than 40,000 dols., and other buildings valued at less than 150,000 dols. The new record included 242,368,000 dols. of Federal building, which is almost all construction for defence or war purposes. It can be assumed that the present year will result in

a much greater defence effort, since most defence agencies are expected to continue construction on a big scale. The record for any one week was that for the week ending October 17, 1940, when 238,793,000 dols. of contracts were placed. On July 2, Mr. Walter J. Douglas, member of the consulting firm of Messrs. Parsons, Klapp, Brinckerhoff, and Douglas, died in New York at the age of 62. Mr. Douglas, from June, 1918, to May, 1919, was maintenance engineer for the Panama Canal and, for some months later, was acting Governor of the Panama Canal Zone. He took an active part in the design and construction of the Detroit-Windsor vehicular tunnel under the Detroit River, and the Scheldt River Tunnel at Antwerp, Belgium. During recent years, he had acted as consultant to the United States Army Engineers on numerous projects. Mr. Douglas was associate editor of Merriman's *American Civil Engineers Hand Book*. On July 22, Mr. Frank E. Weymouth, for the past ten years general manager and chief engineer of the Metropolitan Water District of Southern California, died at Los Angeles at the age of 67. Mr. Weymouth was a recognised authority on irrigation problems. From 1916 to 1920, he served as chief of all construction carried out by the United States Reclamation Service, and from 1920 to 1924 was chief engineer of all activities of that organisation. In 1929, he was retained by the City of Los Angeles, and began studies of the proposed Colorado River Aqueduct. In 1931, he was appointed general manager and chief engineer of the Metropolitan Water District of Southern California, which built the Colorado River Aqueduct at a cost of 220,000,000 dols.

The Carlton Tunnel project at Cripple Creek, Colorado, was completed on July 25, after 670 working days. The tunnel was begun on July 13, 1939, and drains the Cripple Creek gold mining district. In all, 180,000 cub. yd. of Pike's Peak granite was removed by working from one portal, and an average daily advancement of 48½ ft. was made, which is a record for American tunnel construction. Since the tunnel is all through rock, the construction of a lining, either temporary or permanent, was unnecessary. The tunnel is six miles long, 10 ft. by 11 ft. in cross-section, and cost about 1,000,000 dols.

To meet defence needs for electric power, the United States Federal Power Commission has proposed to President Roosevelt the installation of hydro-electric plant with a capacity of one and one-quarter million kilowatts each year during 1943–6. This would involve expenditure on dams and power-houses by the Corps of Engineers of the United States Army, the Bureau of Reclamation, the Tennessee Valley Authority, and other agencies, of about 170,000,000 dols. a year during the next five years, exclusive of electrical equipment. The object is to have a total of 1,250,000 kilowatts brought into service in 1943, 1,275,000 kilowatts in 1944, 1,130,000 kilowatts in 1945 and 1,320,000 kilowatts in 1946.

340-H.P. REMOTE-CONTROLLED PUMPING STATION.

The city of Worcester, Massachusetts, which has a population of about 200,000, is built on undulating ground, a topographical feature which has introduced difficulties into the methods of providing the necessary water supply. Actually, low pressure, high pressure and super-high pressure systems are in use. The larger part of the watershed is tributary to the low pressure system reservoirs and it is necessary to use as much water from this system as possible in order to conserve the supplies which are tributary to the high pressure system. In addition, a pumping station is used to transfer water from one system to the other. Recently a second pumping station has been built to transfer water from the low to the super-high pressure system. The equipment consists of one three-stage centrifugal pump with an output of 300 gallons per minute and two two-stage centrifugal pumps, each with an output of 1,000 gallons per minute. The smaller pump is driven by a 40 h.p. motor and the two larger pumps by 150 h.p. motors. The pumps were constructed by the Dayton Dowd Company and the motors and electric control equipment by the General Electric Company of America. The station has been erected near the principal low pressure service main and the pumps operate against a total head of 395 ft. As the station is situated in a rural area, it has been designed to have the appearance of a country cottage. A photograph of the interior of the station showing the three pumps is reproduced in Fig. 1, on this page.

The reservoir of the super-high pressure system is located 9,100 ft. from the pumping station and the operation of the pumps is controlled by Chronoflo equipment which was supplied by the Builders Iron Foundry, Providence, R.I. This equipment is designed to operate an alarm signal if the water level

REMOTE-CONTROLLED PUMPING STATION.

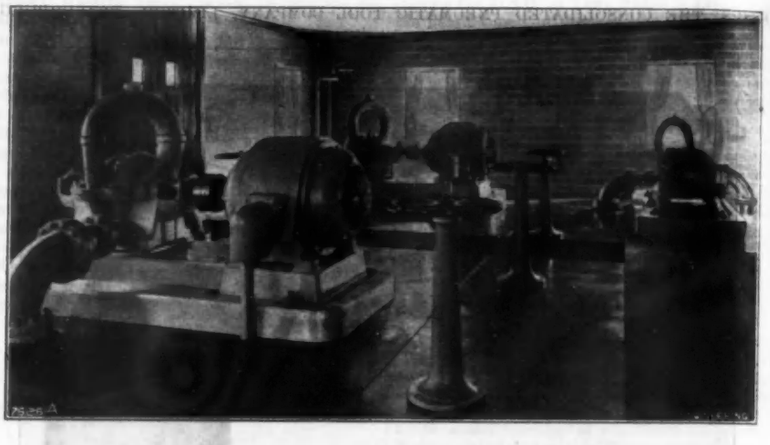


Fig. 1.

becomes abnormally high and to stop the pumps when the normal high-water level is reached. Similarly, it starts the pumps when the water falls to normal low-water level, but when the water level becomes abnormally low the pumps are stopped and an alarm operated. Diagrams of the arrangements at the reservoir and pumping station are given in Figs. 2 and 3, respectively. From Fig. 2 it will be seen that water is admitted from the reservoir *a* to the float chamber through a valve *b* and that in this chamber is installed a float pipe containing a float *c*. The float is connected by a wire rope passing over the pulley of the Chronoflo level-transmitter *d*, and kept in tension by a counterweight. The transmitter is connected to the level-recorder controller in the pumping station by a single wire, with an earth return. This instrument, shown at *e* in Fig. 3, records the reservoir level and also controls the operation of the pumps and the high and low level alarms. The water delivered to the reservoir is measured by a Venturi tube, *f*, in the main 12-in. pump-discharge line and is indicated and recorded by the meter *g*.

The basic telemetering circuit of the Chronoflo indicator and recorder consists of a magnetically-operated mercury switch in the transmitter and a relay and "up" and "down" clutch coils in the receiver. Readings of quantity are translated into cyclic time impulses, the duration of which has a definite relation to the quantity measured. These cyclic time impulses are transmitted to the receiver. The transmitter consists essentially of a cam; a synchronous motor driven from a 110-volt 60-cycle supply; a rocker bar and magnet; and a cam shoe and arm. In operation, the cam rotates at a constant speed of one revolution in 15 seconds and the cam-shoe arm swings in a plane parallel to the face of the cam and between it and the rocker bar. As the leading edge of the cam engages the cam shoe the rocker bar is moved forward, carrying the magnet away from the mercury switch, the contacts of which accordingly close. The position of the cam shoe at any time is determined by the height of the float in the float pipe, this position being controlled by the wire-rope connection from the float. The length of time that the cam shoe rides on the cam, and consequently the period during which the switch is closed, therefore varies with the position of the float and controls the time during which an impulse is transmitted to the receiver.

The receiver in the pumping station consists of a relay, magnetic "up" and "down" clutches, a synchronous motor for driving the clutches and a lever which controls the position of the pen arm of the recorder. As in the transmitter, the motor runs continuously. It drives the gearing of the two clutches in opposite directions. An impulse from the transmitter energises the relay which, in turn, closes the circuit of the "up" clutch, the result being that the pen arm lever is traversed outwards. This travel continues as long as the clutch is engaged. Conversely, when the circuit from the transmitter is open the relay is de-energised. This puts the "down" clutch into operation and the pen arm is moved inward. In addition to indicating and recording the level of the water in the reservoir, the closing of the circuit of the "up" clutch activates a relay which, in turn, closes the circuit of the pump motor starter, so that the pump is operated in accordance with the level conditions in the reservoir.

As there are no tranmission errors between the transmitter and the receiver, the time during which the clutches are engaged must equal the duration of the impulse. Any change in the transmitter is therefore accurately imparted to the receiver and, as both instruments are operated by synchronous motors, they are always in step. Should there be an interruption of the electric supply the instrument will automatically resume operation when the supply is restored. Wide variations in line voltage or resistance do not affect the operation or accuracy of the system, which is dependent only on the duration of the current flow. The whole of the electrical mechanism is enclosed in a moisture-proof case and is designed for operation in a damp atmosphere. Should there be a failure at the transmitter, such as a breakage of the float cable or interruption of the power supply, the receiving instrument would immediately go to its maximum or minimum position depending on the signal being operated at the time of the failure. In doing so it would stop the pumps and operate the alarm. The pump and alarm control switches are adjustable so that they can be set to operate at any point between maximum and minimum. The range of the instrument is from zero to 10 ft., and each control switch moves from the "off" to "on" position when the reservoir level changes about 1 in.

The installation was carried out to the designs of Mr. Earl R. Perry, chief engineer of the Public Works Department of the City of Worcester. We have to thank Mr. Perry for the information upon which this article is based and for the photograph and diagrams illustrating it.

LABOUR NOTES.

THE *Trade Report* of the United Patternmakers' Association states that, in July, the number of unemployed members increased from 26 to 40, the number in receipt of sick benefit from 211 to 231, and the number in receipt of superannuation benefit from 674 to 676. The membership increased from 12,829 to 12,872. "Altogether," Mr. Findlay, the general secretary, says, "we have 11,984 in work this month as against 11,982 last month." The second ballot in the election of a general secretary to succeed Mr. Findlay, who has retired, has resulted in favour of Mr. W. B. Beard for whom 2,253 votes were cast. His opponent, Mr. W. J. McLardy, received 1,961 votes.

Representatives of the Engineering and Allied Employers' National Federation and representatives of the Confederation of Shipbuilding and Engineering Trades discussed at a conference in London last week a claim by the unions for "consideration of the present level of wages in the industry." The meeting was adjourned to give the employers an opportunity to examine the proposals made. Practically all the engineering unions are in the confederation except the Amalgamated Engineering Union and two other organisations, which act independently of it in negotiations with the employers. Later in the week, at Carlisle, representatives of the Confederation discussed its claim for increased wages with representatives of the Shipbuilding Employers' Federation, and it is understood, at the time of writing, that a conference on the wages question has been arranged for this week between the Engineering and Allied Employers' National Federation and the Amalgamated Engineering Union.

A Presidential Decree issued in Washington last week suspended the application of the United States eight-hour day law to mechanics and labourers employed by the War Department on public works necessary to national defence. It affects workers engaged on airfields and in the construction of fortifications and barracks.

Between June 16 and July 14, the numbers of unemployed on the registers decreased by 3,369 in the London area, 1,742 in the Eastern area, 1,400 in the Southern area, 1,252 in the South-Western area, 1,537 in the Midlands, 1,708 in the North Midlands, 4,915 in the North-Eastern area, 3,139 in the North-Western area, 3,686 in the Northern area, 1,479 in Scotland and 432 in Wales. The number of men and boys, registered at employment exchanges in Great Britain as wholly unemployed at July 14, was 113,662—a decrease of 7,900 as compared with June 16. Of the total, 33,048 had been classified by interviewing panels as unsuitable for ordinary industrial employment.

Those registered as on short time or otherwise temporarily suspended from work, on the understanding that they were shortly to return to their former employment, numbered 20,862—an increase of 2,816 as compared with June 16. At July 14, 105,915 women and girls were wholly unemployed. Of these, 3,814 has been classified as unsuitable for normal full-time employment and 4,658 classified as unable, for good cause, to transfer to another area, although employment was not likely to be available locally. The temporarily stopped numbered 25,165 and 671 were unemployed casual workers.

An Essential Work (Dock Labour) Order made last week will, it is hoped, go some way to solve the problem of decasualisation. It will not at present apply to Merseyside and Clydeside ports where the Minister of War Transport is now the employer of all dock labour, but will cover the Port of London and the principal ports on the Bristol Channel, the Firth of Forth, the Humber, the Tees, the Tyne and the Wear. It gives effect to proposals by the National Joint Council for Dock Labour which will form a company to be known as the National Dock Labour Corporation, Limited, whose objects will include the promotion, financing and administration of schemes. The chairman of the corporation and a finance member will be appointed by the Minister of Labour and National Service and three representatives of employers and of workers respectively will be appointed by the council.

The Order will apply to permanent men, though their employment will not be affected by the new arrangements, but other dockers selected for inclusion in the scheme will now always be in employment. Each men will be paid the appropriate rate for his job while at work, and as soon as his job is finished he will automatically come into the employment of the corporation and be paid 5*s.* for each of the 11 half-days (normally Monday to Saturday noon, inclusive) on which he reports as required, but is not allocated to work. It is a condition of the dockers' employment under the scheme that he shall not only report regularly as required, but be prepared to take any suitable work offered.

Regular workers will be eligible for an annual week's holiday, for which they will be paid by the corporation 80*s.* or 75*s.* according to the size of the port. Wages will be paid weekly on Thursdays. The cost of all schemes will be met from a national management fund maintained by the Corporation. Employers under approved schemes will be required to make a contribution to the fund, which will not under present arrangements exceed 25 per cent. of their gross wages bill. The fund will be underwritten by the Exchequer which will, in addition, make a contribution in respect of certain administrative expenses of the corporation.

A working engineer of long experience told a representative of the *Manchester Guardian* the other day that one of the causes of idle time in war factories was the immobility which employers imposed on labour. An employer who was temporarily short of work in any department naturally claimed, he said, to keep his own men till work could be resumed. There was, in his opinion, too little disposition to make those men available to another employer who was in need of them. In particular, that was important where highly skilled men were concerned. "There should be," he added, "a pool of skilled or key men in the region ready for immediate transfer to wherever they were needed." The region referred to is the North West.

A former officer of the Amalgamated Engineering Union, who is now the labour manager in an important engineering concern, said that there was waste of time and human energy in switching over from the production of one design, or type, to another. The man whose labour was not needed while the inevitable changes in machinery were being made should, he went on to say, be transferred to another factory, where he could be used. It was of urgent importance that by closer co-ordination within the region employers should do everything possible to facilitate such a transfer of labour—temporarily redundant in one factory but urgently needed in another not far away.

Writing in the August issue of the *Report* of the Boilermakers' and Iron and Steel Shipbuilders' Society, Mr. Mark Hodgson, the general secretary of the organisation, expresses the opinion that the White Paper on price stabilisation and industrial policy issued by the Government may very well serve as an inducement to employers to refuse legitimate wage increases. "The need for 'pinning down' wages at their present level," he says, "is stressed in the statement, but the arguments are much the same as those submitted to the General Council of the Trades Union Congress on behalf of the Government in December, 1939. The General Council considered the arguments at that time and expressed the emphatic view that any attempt to control movements for increases of wages was impracticable and undesirable—a view which was endorsed by the Congress at Southport in October last year. That conviction is just as emphatically confirmed to-day. We are not satisfied with the advances secured since the war began, regarding them as inadequate . . . The Government's spokesmen have expressed the opinion that the machinery for regulating wages has functioned satisfactorily, and it is certain that any attempt to interfere with that system will be deeply resented."

Agreement is recorded in the August issue of the Amalgamated Engineering Union's *Journal* with the General Council's criticism of the White Paper that its likely effect will be to influence employers and tribunals against applications for wage increases. Any attempt to stabilise existing wage rates would, it is claimed, merely stereotype wide disparities and inequalities as between different groups of workpeople.

The executive of the New Zealand Federation of Labour reported to the fourth annual conference that the Industrial Emergency Council had had before it an application from the New Zealand Employers' Federation for a general extension of working hours to 44 per week. No general extension of hours, it was added, had been, or would be, agreed to. A close watch was being kept on all applications for alterations of awards and agreements and only those definitely of an essential character were being granted. A resolution calling upon the Federation to press for the introduction of a 40-hour five-day week in industries not yet enjoying this concession was adopted after a long discussion.

STEAM AND DIESEL-ELECTRIC LOCOMOTIVE OPERATION.

AN interesting summary of the present position regarding steam and Diesel-electric locomotives in the United States is given in a paper by Mr. E. E. Chapman, read before the American Society of Mechanical Engineers at its recent semi-annual meeting. After a rapid review of the development of the steam locomotive on American railways since its introduction, Mr. Chapman indicates the relative proportions of the different types of locomotive by tabulating the domestic orders booked over a period of five years, from 1936 to 1940. From this it is apparent that the Diesel-electric locomotive is rapidly achieving popularity, as the orders for engines of this type in 1936 were only 77, while in 1940 they were 462. The orders for steam locomotives, on the other hand, show a decline, 435 having been placed in 1936 and 219 in 1940. The tabulated totals for the five years are:—steam locomotives 958, Diesel-electric locomotives 1,090, and electric locomotives 134. These figures do not, of course, present a complete picture, since only orders placed with locomotive manufacturers are concerned, but they do, at least, indicate the present trend. Roughly, the steam locomotive and the Diesel-electric locomotive have been purchased in equal numbers. The electric locomotive, as it involves track modification, is far behind the other two types, and the yearly orders show neither a steady increase nor a steady decline.

The paper includes a very complete table of the principal dimensions and characteristics of typical engines, 4,000 h.p. and 5,400 h.p. Diesel-electric locomotives being compared with 4-6-4, 4-8-4 and 2-10-4 steam locomotives; of particular interest are the figures relating to drawbar horsepower which are given for 11 travelling speeds ranging from 10 m.p.h. to 110 m.p.h. The 4,000 h.p. Diesel-electric passenger locomotive and the 4-6-4 steam locomotive are similar in essentials, but at speeds below 29 m.p.h. and above 87 m.p.h. the Diesel locomotive has more horse-power available at the drawbar than the 4-6-4 steam locomotive. The Diesel locomotive has 16 driving wheels, 3 ft. in diameter, the total load on the drivers being 426,800 lb., and the rigid wheelbase is 14 ft. 1 in. The steam locomotive has six driving wheels, 6 ft. in diameter, with a load of 213,440 lb., the rigid wheelbase being 14 ft. 6 in. It is claimed that the stresses in the rails are lower with the Diesel locomotive than with the steam locomotive.

The 5,400 h.p. Diesel locomotive mentioned above is for goods traffic and is superior, as regards drawbar horse-power, to the 4-8-4 steam locomotive throughout its speed range. The steam locomotive is, however, designed for a maximum speed of 90 m.p.h. while the Diesel locomotive has a maximum speed of 77 m.p.h. The Diesel locomotive has 32 driving wheels, 3 ft. 4 in. in diameter, a rigid wheelbase of 9 ft., and a total load on the drivers of 923,600 lb. The eight driving wheels of the comparable steam locomotive are 6 ft. 8 in. in diameter, the rigid wheelbase is 13 ft. 10 in., and the total load on the drivers 286,890 lb. The 2-10-4 steam locomotive develops more horse-power at the drawbar than the 5,400 h.p. Diesel locomotive at speeds above 29 m.p.h. Below this speed the Diesel locomotive has a marked superiority; thus at 10 m.p.h. it develops 3,870 h.p. as against 2,430 h.p. in the case of the steam locomotive. This greater power at low speeds gives the Diesel locomotive a distinct advantage not only in starting and accelerating heavy trains, but also in maintaining higher speeds on gradients. The starting tractive effort of the 4,000 h.p. Diesel locomotive is 106,700 lb. and that of the 5,400 h.p. engine is 220,000 lb. Those of the three steam locomotives referred to above are 49,300 lb., 66,000 lb. and 93,000 lb., respectively.

The overall thermal efficiency of the Diesel-electric locomotive is stated to be 26 per cent. to 28 per cent. on the average, as against 6 per cent. to 8 per cent. in the case of the comparable steam locomotive, this higher efficiency resulting in a reduction of the fuel to be carried and an increase in the operating time available between re-fuellings. The average water cost for a steam locomotive is approximately 10 per cent. of the fuel cost. The water cost for goods Diesel-electric locomotives is practically negligible and in the passenger locomotive of the same type it is not over 10 per cent. of the water cost for the steam locomotive, the water being required in the Diesel-electric locomotive for conversion into steam for heating or air-conditioning the train. The lower fuel consumption of the Diesel-electric locomotive referred to above is offset to some extent by a higher unit cost of fuel, but it is claimed that the net cost of fuel consumed per unit of power developed by it is approximately one half to two-thirds that of the unit fuel cost of comparable steam locomotives. This ratio does not hold invariably; thus, a railway having ready access to supplies of suitable coal at low cost is obviously in an advantageous position, and a railway close to oil fields and refineries may be

able to secure a supply of residual fuel oil at a low cost. The steam locomotive can thus be operated on either coal or oil, but the Diesel-electric locomotive can only operate on a single fuel, so that the competitive influence of alternative fuels is wanting. The Diesel-electric locomotive is at a disadvantage as regards the over-all cost of lubrication. Lubricating oil is needed in larger quantity than for the steam locomotive and a higher-priced oil must be used. The net cost of lubrication for the Diesel-electric locomotive is approximately double that for the steam locomotive. With both types, however, the lubricating cost is a relatively small percentage of the total cost of operation.

The initial cost of the Diesel-electric locomotive as compared with the steam locomotive is one of its disadvantages, the costs per horse-power being approximately in the ratio of 87·5 to 35. It is stated that the greater utilisation of the Diesel-electric locomotive helps to reduce this ratio by keeping down the overhead cost per mile of operation. The mileage per locomotive per annum may be used to indicate the relative utilisation. For passenger Diesel-electric locomotives, the average mileage per annum is 250,000 with a maximum monthly mileage of 27,000, as compared with 180,000 miles per annum and a high monthly mileage of 18,000 to 19,000 for modern steam passenger locomotives. The Diesel-electric locomotive has the advantage that it can be accommodated to the train to be handled; thus, on long runs with varying gradients one or more engines may be cut out entirely on the easier gradients. This practice of not utilising all the units continuously permits some inspection and light maintenance of engines to be done, while the locomotive is in service, but it cannot be denied that the close tolerances and the interlocking of electrical and mechanical equipment call for a higher degree of maintenance in the Diesel-electric locomotive than in the steam locomotive. The general question of the extent and method of maintenance of Diesel-electric locomotives would seem to be still a subject for debate, but it is stated that the actual comparative maintenance costs of the two types of traction are nearly equal, as far as can be ascertained in the absence of concrete data.

On the question of the relative life of the locomotives, there is, naturally, nothing definite to go upon with regard to the Diesel-electric locomotive, but it may be noted that depreciation rates are based on an assumed expectation of 15 years of service for passenger and freight locomotives of this type and of 20 years for the shunting Diesel-electric locomotive, against an accepted figure of approximately 28 years for steam locomotive. The expectation of life of the Diesel locomotive may, however, be extended as experience with it accumulates. An advantage of the Diesel locomotive is the reduction in delay time due to taking in fuel and water as well as its ability to run for long distances between fuel and water stations as compared with steam locomotives. The reduction in delay time permits of higher sustained speed without the necessity for running at high maximum speeds. The high available drawbar horse-power in the lower speed range gives the Diesel locomotive an advantage in that considerably less time is consumed in accelerating to the speed required to keep to the timetable.

An interesting section of the paper is that dealing with dynamic braking on goods trains, or more correctly the controlling of the speed of these trains on long falling gradients. In this form of braking the motors are converted into generators, the current generated being dissipated as heat through air-cooled resistance grids on the roof of the locomotive. The dynamic brakes are designed to hold, at a definite speed on a falling gradient, the same train weight that the locomotive could haul up the same gradient at the same speed. Trials of the dynamic brake have shown that the amount of train air braking required was approximately 25 per cent. of that required by conventional braking with train air brakes. The possibility of reduced maintenance owing to less wheel and brake-shoe wear is of sufficient importance to encourage further development of this brake for locomotives in mountain service.

In summing up the results of Diesel-electric locomotive operation in main-line service, the paper records that the scheduled times for passenger services between important terminals has been reduced and that there has been a steadily increasing number of higher-speed passenger trains placed in service by various railway companies. In goods traffics it has been possible to increase both the tonnage hauled and the average speed between terminal stations. The power performance, particularly in the lower speed ranges, has made it practicable to operate trains over most ruling gradients without additional engine help. The uniform torque on the driving wheels of Diesel-electric locomotives and the distribution of the tractive effort over a greater number of driving wheels is stated to be of marked benefit in bad weather under adverse rail conditions since the timetable service can be adhered to without any reduction in the weight of the train handled.

THE ADMIRALTY EXPERIMENT WORKS, TORQUAY.*

By R. W. L. GAWN, R.C.N.C.

(*Continued from page* 140.)

BY far the most important of Froude's early experiments, prior to the establishment of the experiment tank, were carried out in a creek off Dartmouth Harbour in the autumn of 1867. Froude's unpublished notes show that, to ensure obtaining accurate results, he was at pains to take all possible precautions, including the use of an extremely sensitive screw log for measuring the speed of the towing launch. In the report of the British Association in 1869, Froude stated: "In verification and illustration of the foregoing views, I tried, in the autumn of 1867, a large number of resistance experiments on a pair of models of contrasted forms, 6 ft. long, by towing them simultaneously from the ends of a pair of 10-ft. scale-beams connected with self-recording dynamometric apparatus, and mounted on booms projecting sideways from the nose of a steam-launch, lent me for the purpose by Mr. Bidder. One was of the wave-line type; the other, having the same length, form of midship-section, and displacement, had large rounded ends. I also tried similar experiments with a pair of very nearly similar models of twice the dimensions and eight times the displacement. I had also previously obtained a series of experimental results of the same kind, but with less successful apparatus, from a similar pair of models, 3 ft. long. These data enabled me to compile for each model a diagram of resistance in terms of velocity."

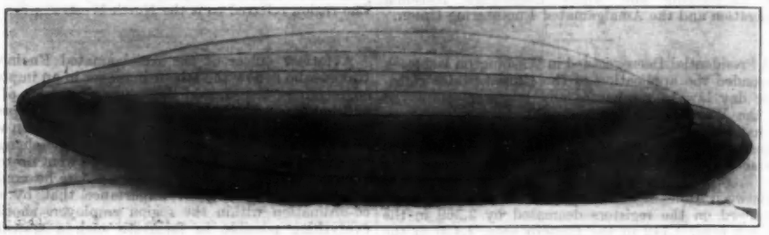


FIG. 6. "SWAN" MODEL.

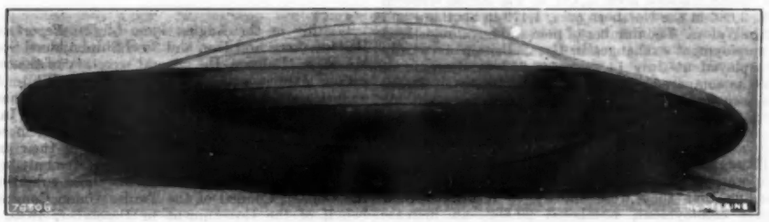


FIG. 7. "RAVEN" MODEL.

Recent photographs of the largest pair of models are shown in Figs. 6 and 7, on this page, and the resistance diagrams, as published in the British Association report, are given in Figs. 8 to 12, opposite. Their general agreement was held by Froude to justify the Law of Comparison, although, as he remarked, the correspondence was not so close as at first sight appeared, chiefly because of an excess resistance of the 3-ft. models. This was attributed to the model being small enough for the results to be within the range of perceptible viscosity effects. The 12-ft. models also had a slight excess of resistance as compared with the 6 ft., which Froude thought might have been due to certain minor differences in form, and also to some interference from the towing boat. He concludes: "It is true that the circumstances under which my experiments were tried did not admit of such exactness as to render them absolutely conclusive as the sole basis of the theory of comparative resistance in terms of dimension. Nor do I by any means pretend to be certain that there is no element of resistance other than I have taken account of in my theoretical justification of it. But if any such do exist, they can be detected, and the laws of their operation discovered with far greater facility and completeness by small scale than by full-size experiments. And I contend that unless the reliability of the small-scale experiments is emphatically disproved, it is useless to spend vast sums of money upon full-size trials, which, after all, may be misdirected, unless the ground is thoroughly cleared beforehand by an exhaustive investigation on small scale."

In view of the controversy referred to on page 139, *ante*, it was perhaps natural that Froude's first experiments should have been carried out on these two forms. He observed that an abnormal form, suggested by the appearance of water birds when swimming, experiences, at a moderate speed, considerably less resistance than the wave-line form which was the accredited representative of the form of least resistance. This proved that there was no ground for certainty that there was even an approximation to the best form unless a wide variety of shapes are tested. Froude also commented on the fact that there was no information on the very important question of dimensions, although economy of fuel and building are very much involved in the settlement of that question. These two sets of models were afterwards called the Swan and Raven, respectively; great, medium, and small according to size. They were reproduced among the first models made in paraffin wax in the Torquay Tank, and the results found to check up very well. It is fascinating to note, in the light of our present-day experience with ship forms, that the Swan bow, which can be likened to the first bulbous-bow model for which reliable results are available, not only compares much better than the hollow-lined form at top speeds, but shows a distinct disadvantage at low speeds. This will be recognised as a characteristic effect of many features of a ship's form, and is one of those perverse results which greatly add to the complication of the designer's task. Since this test of the early bulbous-bow model, similar bows of different degrees of fullness have been fitted to many models of other ships, including battleships, cruisers, and destroyers, since Froude's day down to and including the present day. Despite a fair amount of research, however, it has not been found possible with any bulbous-bow form to overcome the disadvantage at low speed which is a feature of this early experiment. In short, as Froude found in 1867, the bulbous bow may be good for high speeds where wave-making is present, but it imposes a serious restriction on endurance at economic speeds. Several times this conclusion has been challenged, only to be verified.

The last report forwarded from Torquay, dated January 27, 1886, was on a 19-knot "torpedo-boat catcher" about 200 ft. long. R. E. Froude refers to the Swan bow experiments of his father in 1867 and remarks: "The principle of the Swan bow may be said to consist in the use, instead of an ordinary form of specified length, of an ordinary form of greater length brought back to the specified length by 'snubbing' at the forward end. The form thus produced possesses, so far as the transverse wave-making resistance is concerned, nearly the full advantage of the extra length of the 'unsnubbed' form—at the expense of the extra resistance due to the surge and diverging waves, made by the extra blunt 'snubbed' entrance, and at the speeds at which the transverse wave-making becomes excessive the gain on the former account greatly outweighs the loss on the latter." This is the first mention of Froude's expedient of "snubbing" to improve performance. The Swan bow alternative proved inferior in this investigation, better results being obtained with a half-angle of 22 deg.

* Paper presented to the Institution of Naval Architects. Abridged.

THE ADMIRALTY EXPERIMENT WORKS, TORQUAY.

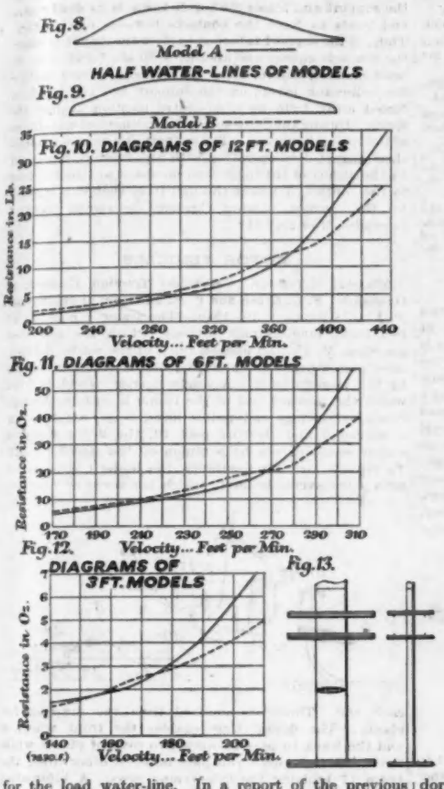


FIG. 14. DYNAMOMETER EXPERIMENTS ON H.M.S. "CONQUEST."

for the load water-line. In a report of the previous month on H.M.S. Scout, Froude notes that the model had a ram bow with the water-lines carried well out to it, thus giving increased displacement below water, and tending to increase effective length, and so diminish resistance at the highest speeds. He refers also to the advantage of the bow torpedo tube in this respect on the model of the torpedo ram Polyphemus, tested in 1878.

Although William Froude did not fully propound the streamline theory of resistance until 1875, it is clear from his proposals to the Admiralty in 1868 that he had then visualised the theory. Many took part in originating or perfecting the general theory of streamline action, especially Rankine, Stokes and Sir William Thomson, and Froude only claimed to be insisting on views established by these and other eminent mathematicians. His exposition of the application of the theory to ship resistance in 1875, so modestly described by himself as elementary, was, by its beautiful simplicity, masterly in perception and of far-reaching effect. By this early date, Froude had established that skin friction accounts for about 80 per cent. to 90 per cent. of the total resistance at low speeds, 45 per cent. to 60 per cent. at high speeds, and a larger proportion when the surface of the hull becomes foul. Eddy-making was recognised as being proportional to the skin-friction resistance, and 8 per cent. of the skin friction was regarded as a reasonable allowance. The remainder of the resistance was due to wave-making. This early subdivision of resistance into its components is still accepted and the broad proportions still apply to many of our present-day ships. The classical skin-friction resistance experiments formed the first subject reported on to the Admiralty. This famous investigation has been fully dealt with in the original publication by Froude* and also more recently by Mr. M. P. Payne.† The skin-friction constants evaluated by William Froude are still in general use, subject to the small modifications embodied by R. E. Froude a few years later.

It was explicitly stated by Froude, and has been tacitly accepted ever since, that his simple hypothesis requires further experimental verification especially for long and fast ships. Many elegant and logical attempts have been made, both by theory and experiment, to substitute alternative methods and constants to allow for the shape and surface roughness of a plated and riveted ship. In 1933, an international conference of Tank Superintendents at The Hague endorsed Froude's constants, a decision reaffirmed by a later conference at Paris in 1935. At the last conference, held in Berlin in 1937, the author recalls a lively debate on this subject, when there was strong and logical, but to his mind premature, support, not so much for an alternative method in principle, but one definitely different in detail, founded on the conception of surface roughness defined by grain size on the lines of Prandtl's theories. It was eventually agreed to defer a decision until a projected conference in Rome in the autumn of 1939, fresh investigations being carried out meanwhile by the experiment tanks represented at the conference. Froude's simple deductions from the results of a not extensive or elaborate series of experiments, as viewed by modern standards, give a close approximation to the magnitude of the skin-friction resistance sufficient for most practical purposes. It is remarkable that his method still holds good, despite the wonderful developments in the mathematical treatment of fluid flow as affecting skin friction and boundary layer theory in our times. Froude's early confirmation of his views on the importance of skin friction was of primary importance as regards hull design, not only because it afforded a basis for estimate of the power required to propel a ship at a given speed, but also because it enabled the relative importance of wave-making resistance to be assessed and so paved the way for investigating the influence of form and dimensions on ship propulsion.

As a direct result of these investigations, the way was open to the naval architect to evaluate the desirable dimensions of a ship with more confidence. Previously the abstract "form of least resistance" was a favourite pursuit of many eminent designers, but the Torquay investigations showed that the object was so to arrange the dimensions and shape of the ship that the respective elements of resistance should be a minimum for the speed in view, consistent with other requirements of the design. Thus, for a given displacement, a ship could be long and narrow, in which case the wave-making and eddy resistance would be small and skin friction excessive, or short and broad, when the reverse obtained. Between these two extremes the optimum form is to be found and the solution of this was one of the most important results obtained at the Torquay Tank. Wave-making effects have been primarily dealt with in two important papers, one by William Froude in 1877* and the other by his son in 1881.† These investigations contradicted the views of Scott Russell, who regarded the bow as producing a solitary wave of translation, a conception widely accepted until Froude demonstrated by experiment and theory that the wave system was divided into two systems of gregarious transverse waves, one produced by the bow and the other near the stern, together with the bow and stern divergent wave systems. The heights and lengths of these waves were shown to vary systematically with the speed. It was established that the crest of the bow wave echo should always be in a suitable relation to the stern, so as "to swallow up that wave instead of making any of its own." R. E. Froude's straightforward solution in his 1881 paper is as sound to-day as it was 60 years ago and, although elaborated by later workers, it gives reliable results in its original form. Imagine the enlightenment such explanations afforded, when in some ships the addition of parallel body was made with great benefit to propulsion, whereas in other cases the result was a failure. The work at Torquay did not produce a specific formula to explain such discrepancies, but this is not surprising, for no subsequent investigation has yet afforded any specific solution. The early investigations opened the way to that confident prediction of dimensions and forms that is now available. It was demonstrated that there was a limit of speed beyond which there is a disproportionate increase in resistance, which is determined by the wave-making features, and these in turn are governed by the length of entrance and run and the area of the midship section.

In an address to the British Association in 1875, William Froude clearly explained the cause of eddy resistance as incidental to friction and viscosity preventing "the nice adjustments of pressure and velocity, thereby diverting the restitution of streamline forces at the stern and so reducing resistance." Abrupt features, such as thick sternposts and stems, were also identified as fruitful sources of eddy resistance. In addition, the shape of rudders, shaft bossings and tubes came in for attention. Eddy resistance, however, was not important in well-faired ships of easy lines until the advent of twin-screw designs of higher speed, involving the fitting of four shaft struts, which caused the Admiralty to request Froude to carry out a special investigation. Shaft-bracket arms of H.M.S. Iris, half full size, were tested in 1878. Each strut was 2 ft. 6 in. long, bounded at the ends by iron plates square to the axis and parallel to the line of motion, as shown in Fig. 13, herewith. The strut was upright, the top end being immersed about 6 in. The plates were intended to confine the motion to two dimensions, and a third plate, designed to defeat wave formation, was fitted just below the water surface. Some difficulty was found in eliminating plate and stem resistance accurately, and neither depth of immersion nor top plate was entirely

* "Experiments on the Surface Friction Experienced by a Plane Moving Through Water." *British Association Reports* (1872).

† *Trans. I.N.A.*, vol. 78, page 93 (1936).

* *Trans. I.N.A.*, vol. 18, page 77 (1877).

† *Ibid.*, vol. 22, page 220 (1881).

successful in eliminating wave resistance. Some of the sections tested were of elliptical form without straight tails. In the ensuing 60 years, an extraordinarily large number of struts have been tested in wind tunnels and tanks, and some of the later results are also shown, from which the remarkably high standard of the Torquay sections can be appreciated. Shaft webs and tubes were also the subject of large-scale model experiments in 1878, and information was obtained of the angle at which the web should be set in regard to propeller reaction as well as hull resistance. These experiments were made in conjunction with a model of H.M.S. Iris, $\frac{1}{12}$th full size. From the large-scale strut experiments, Froude deduced that resistance of these features is to scale about half of that in the model hull. It was concluded that the resistance of the existing brackets, of elliptical section, was 10½ per cent. of that of naked hull, reduced to 6 per cent. by fitting a tail to the ellipse and a sharp edge forward, and to 4½ per cent. by dispensing with the sharp forward end and preserving the elliptical head. Two formulæ evolved as the result of these and other experiments for the resistance of shaft brackets and shaft tubes have been found consistently useful since and are reproduced in Appendix II.* Their substantive accuracy, subject to the appropriateness of the design, has been well verified by subsequent model experiments and speed-trial analysis. On the ordinary model scale, such eddy resistance is liable to exaggeration on account of viscosity effects, and it was the full realisation of this which led to the experiments being made on specially large models of the features. In appreciation of this the procedure of easing the blunt half sidings of models by a gradual 4 to 1 taper was initiated to prevent undue exaggeration of eddy resistance in the model. Froude's pithy enunciation of the important fact that "it is blunt tails rather than blunt noses that cause eddies," dates from these early experiments. A photograph of the stern of H.M.S. Conquest, a cruiser of the 1870 epoch (see Fig. 14, on page 159), shows the need for improvement. Some attention has been paid to fairing off the sternpost abaft the propeller, and also in parts before the propeller, but there is an absence of taper in the wooden rudder. It is interesting that the rudder design incorporates a fixed element before the rudder, for which arrangement special advantages have been claimed.

During the famous Greyhound trials, William Froude found an opportunity to obtain an approximate measure of the air resistance by allowing the ship to drift before the wind, and deduced that the air resistance was 330 lb. at 15 knots. This has been more recently evaluated as equivalent to 0·0037 lb. per square foot per knot (or $0{\cdot}43\ \rho/g\ A\ V^2$) (where ρ = density of air, A = total transverse projected area, and V = relative wind speed), assuming the resistance to vary as the square of the speed and as the projected area of the portion of the ship above water, square to the direction of motion. This trial was characteristic of Froude's attitude of not taking anything for granted. It was thus demonstrated that air resistance was of little account on a calm day, but might be important in a high wind. Much attention was devoted to this subject in later measured-mile speed trials, when the wind velocity and direction were carefully ascertained on each individual run by cup-anemometers recording electrically on a timer; for example, on the jack staff in H.M.S. Vulcan, on the poop 8 ft. above the deck in H.M.S. Gleaner, and one each side on the fore bridge in H.M.S. Royal Arthur. The true relative wind was ascertained vectorially and the total air resistance of the ship, including the effect of wind, computed by the formula: force in tons = $K\ w^2 \sin \phi$, where w is relative wind in knots and ϕ the angle forward of the beam. The coefficient K should bear some relation to the nature and extent of the above-water features of the vessel, and in ships similarly proportioned and rigged should be proportional to the square of the dimensions. The value deduced for Vulcan from the Greyhound trials was K = 0·003, and this was fairly well checked on the ship trials, when it was found that the wind blew strongly along the measured-mile course. If anything, the value of K was found to be on the high side. This formula has been found of consistent use in speed-trial analysis at Haslar, and has been reasonably checked in recent years by tests on a warship's upper works submerged in water. Applied to a modern warship, the formula suggests an air resistance of about 2½ per cent., which compares with about 2 per cent. deduced from the model experiments on the upper works.

(To be continued.)

GOLD PRODUCTION IN SOUTH AFRICA.—The output of gold from the Transvaal during July totalled 1,225,772 oz. This constituted a record, the previous highest total, reached in May, 1940, having been 1,219,068 oz.

* To be printed later.—ED., E.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

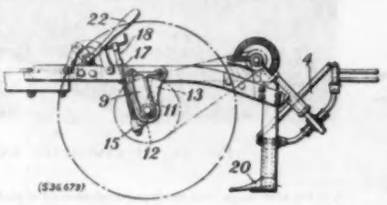
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

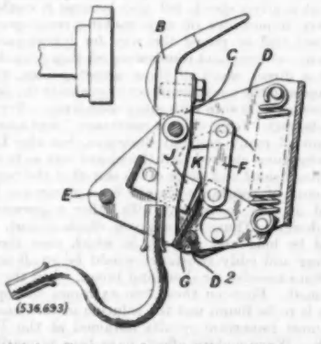
AGRICULTURAL APPLIANCES.

536,679. Potato-Digging Machine. Blackstone and Company, Limited, of Stamford, and J. A. Lewis, of Bedford. (2 *Figs.*) October 4, 1939.—The invention is an arrangement whereby vertical adjustment of the share and tines is obtained without tilting the frame laterally. A digging share 20 and a revolving tine wheel 4 are carried by the frame, which is supported on road wheels. The tine wheel 4 is driven by chain and bevel gearing from the road-wheel axle. The axle bearings engage in slots 9 in side brackets fixed to the main frame and can be adjusted in the slots to raise or lower the axle relatively to the frame. From the axle bearings, lugs 11, 12 project to the rear and forwards, respectively. The rearward lugs 11 are mounted next to the corresponding side brackets and are connected by links 13 to the frame. The forward lugs 12 are coupled together at the centre of the frame by a swivel block 15. Another swivel block 17 is pivoted to a cross stay of the main frame and through it passes a screwed rod 18, which is attached to the lower swivel block. By rotating the rod, the axle bearings are raised or lowered equally so that the frame is kept level and the cutting angle of the share 20 is maintained, whatever the depth of work for which it is set. For raising the back of the frame, with the digging share and the tine wheel, when turning at the ends of the rows of potatoes or when travelling on a road, a spindle on the frame is rotated by a hand lever 22 and operates a crank and link connection to the draw-bar. The front of the frame is thus depressed relatively to the draw-bar, and rocks on the axle to raise the tines and share. (*Accepted May* 22, 1941.)



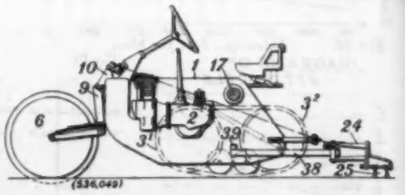
ELECTRICAL APPARATUS.

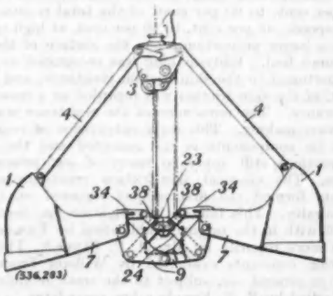
536,693. Butt-Contact Circuit-Breaker. A. Reyrolle and Company, Limited, of Hebburn-on-Tyne, and A. T. Robertson, of Newcastle-on-Tyne. (2 *Figs.*) November 22, 1939.—The breaker is designed to resist the tendency of the contacts to separate under the influence of electromagnetic forces set up at the instant of initial closing of the circuit. This separation may cause arcing of sufficient intensity to produce welding of the contacts, and it is therefore essential to have the maximum force available at the instant of closing the circuit. The butt-contact B is carried by a bell-crank C pivoted on a support D which, in turn is pivoted at E. The circuit-breaker is closed by rotating the support D. The bell-crank is connected to the support by a toggle F, G pivoted at D^2 to the support D. A spring is connected between the lower arm G of the toggle and a point on the support and biases the toggle towards its dead centre and tends to force the contacts towards one another. Thus, as the support is turned to close the circuit-breaker, the contacts engage one another with the toggle near its dead-centre position. As the support moves farther the bell-crank pivots on the support and the toggle is forced away from its dead-centre position against the spring. During this movement, the mechanical advantage of the spring decreases. The support also carries a horse-shoe magnet J co-operating with an armature K carried by the arm G of the toggle and mounted so that the lead to the contact B passes through it so that it is excited by the current passing through the circuit-breaker. (*Accepted May* 23, 1941.)



MOTOR VEHICLES.

536,049. Tractor. Roadless Traction Limited, of Hounslow. F. G. Green and P. H. Johnson, of Hounslow. (3 *Figs.*) January 10, 1940.—The frame 1 consists of two main longitudinals between which are mounted sprockets 3^1, 3^2. An endless track of the rubber-jointed type passes over the sprockets, one of which is driven by the power unit 2. A single steering wheel 6, from which the forward end of the frame is sprung through laminated springs and radius links, is steered through a stirrup 9 and steering post 10, the latter carrying a gear sector driven by a pinion on the steering shaft. To provide for lateral stability, the frame 1 is provided with a transverse beam 17 which has a castor wheel at each end. These are omitted from the drawing for clarity. The design thus enables the front wheel 6 and the track to pass between two rows of plants while the stabilising wheels can pass between other rows, the beam 17 bridging the intervening rows. A bifurcated tool bar 38 is pivoted to the frame by the pivot bar 39, which is located approximately at the longitudinal centre of the track. The tool bar is connected to a frame 24 which carries the implements 25, the whole bar being swung upwards by a lever to lift the frame and implements. The frame 24 is vertically pivoted on the tool bar 38, and is coupled to the front wheel 6. The frame thus conforms to the steering of the front wheel, the movement of the frame being opposite to that of the wheel 6. (*Accepted* May 1, 1941.)



LIFTING AND HAULING APPLIANCES.

536,283. Mechanical Grab. Priestman Brothers Limited, of Hull, and A. Cook, of Hull. (4 *Figs.*) January 10, 1940.—The grab is of the wide opening jaw type in which the jaws exert a combined digging and scraping action, and is designed to ensure that sufficient turning movement is exerted on the jaws during the final stages of the closing movement. The jaws 1 are pivoted at their outer ends to spreader arms 4 which are pinned at their upper ends to the grab head 3. The upward extensions 7 of the jaws are united by links 9 pinned together, and tied at 23 to the crosshead by links 24, the inner ends of which carry intermeshing gear teeth. Lugs 34 on the extensions 7 are connected by links 38 to the pivot pins 23. During the later stages of the closing movement, the angles between the links 24, 38 are decreasing and the upper ends of the lugs 34 are being forced apart. Thus, a positive turning moment is exerted on the jaws which materially assists the last stage of the closing movement. (*Accepted May* 8, 1941.)